Original Research Article

Studies on the Antibacterial Activity and Chemical Composition of Methanol Extract of *Cochlospermum Tinctorium* Root

ABSTRACT

The antibacterial activity of the methanol extract of *Cochlospermum tinctorium* root powder were tested against 10 strains of antibiotic resistant food-borne pathogens *Staphylococcus aureus* and *Listeria monocytogene* whereby the pathogens showed sensitivity at different concentration. The antibacterial activity of the methanol extract of *Cochlospermum tinctorium* root powder were tested against Ten (10) strains of antibiotic resistant food-borne pathogens *Staphylococcus aureus* and *Listeria monocytogene* procured from Microbiology Research Laboratory Usman Danfodiyo University Sokoto. Methanol was used for extraction. The results revealed the percentage yield of the methanol extract 5.17%. The methanol extract of *Cochlospermum tinctorium* was effective in inhibiting the isolates at high concentration of 10 mg/mL. The results thin layer chromatography revealed four spots with R_f values 0.02, 0.37, 0.44 and 0.80 respectively. The GC-MS analysis of the active methanol extract of *Cochlospermum tinctorium* root powder revealed the existence of major peaks 1-(+)-Ascorbic acid 2,6-dihexadecanoate (R.T: 13.666), Diethyl phthalate (R.T: 10.440), Undecyl acetate (R.T: 10.007), 3-tetradecanone (R.T: 9.793)**,** 3-hexadecanone (R.T: 12.427**)**.The result provided evidence that *Cochlospermum tinctorium* root powder has immense potential to be used in the area of pharmacology as it possess antimicrobial activity against the antibiotic resistant food-borne pathogens, thus could be exploited as alternative antimicrobial drugs for the treatment of diseases caused by this pathogens.

Keywords: Methanol, *Cochlospermum tinctorium,* Antibiotic-resistant, Pharmacology and Pathogens.

Introduction

Cochlospermum tinctorium is a shrub that can grow up to 10 meters high. The slash is iodine-like in colour. Leaves are alternate, palmately lobed with stipules. Inflorescence consists of brightly colored yellow flowers that are regular and borne in racemes or panicles. Fruits are elongated, 3-5 valve, capsules containing seeds that are embedded in cotton foam. The seeds are bean-shaped with brown to black colour. It contains oily endosperm with broad cotyledon, it is a savannah plant found on fallow farm lands [1]. The bark, roots and seeds are used in the treatment of various ailments in different areas around the world. In Nigeria, a decoction of the root is used for treating gonorrhoea. It is used in the treatment of diabetes by the Igede people of Benue State [2]. The leaves are used in the treatment of malaria fever in some parts of Kogi State. In Mali the plant is variously used against jaundice, abdominal pains, haemorrhoids,

intestinal worms, helminth, bilhazia and hepatitis. It was also reported to have been used against gastrointestinal diseases like ulcer, stomach ache, flatulence and constipation [3].

Staphylococcus aureus is capable of reproducing in wide range of physical conditions of temperature, pH and salt concerntration [4]. *Staphylococcus aureus* can be found in a variety of foods because of its ability to reside broad array of spaces in close proximity of human beings [5][6]. Moreover, *S. aureus* is a leading cause of foodborne illness worldwide causing 2.41 million illnesses per year in the United State alone [7]. The basic cause of all these reported illness is by consuming food contaminated with *S. aureus* derived toxins. About 1000 patients are hospitalized based on the severity of infection; 6 deaths may happen each year [7]. Severity of the symptoms depends on the amount of toxin consumed [8]. Disease condition is caused when the concerntration of toxin in the body is increased from 10^5 CFU/ml. Disease symptoms generally appear in 1-6 hours after eating the contaminated food.

Listeria monocytogenes, a member of the genus Listeria, naturally occurs in agricultural environments such as soil, manure and water [9]. Scientific literature frequently discusses the ability of this microorganism to survive in the food-processing, produce-packing environment and equipment, diverse habitat like soil, silage, marine and freshwater, sewage, vegetation, domestic and wild animal as well as humans [10][11][12]. Adzitey and Huda [13] pointed out that studies on *L. Monocytogene* and its association with foods is important to create more awareness in order to reduce its colonisation, transmission, cross contaminations and infections. Even though the reasons for the increasing number of pathogens causing food and water diseases in North America are found in Nigeria, occurence of food-borne *Listerial* infectionis not well reported. The reasons for the increasing number of pathogens include improved ability to isolate and identify organisms, import of a variety of products from abroad, large animal feeding stations and an increase in the number of immune compromised persons [14]. Hoelzer *et al* [15] have reported that one major determinant of the listeriosis risk is the ability of a food to support the growth of *L. monocytogenes* during storage but data regarding the ability to support growth of the organisms are scarce or non-existent for many produce commodities.

Nigeria is bestowed with rich and diverse resources of plant wealth including an enormously large number of medicinal plants which are used extensively as anti-tumor, immune-modulators, anti-diabetics, purgatives,anti-inflammatory, anti-oxidants and antidotes. Most of these medicinal plants are undocumented in regards to their phytochemical characteristics, pharmacognostic characters, extractive value and also antibacterial activities. Since plants producea diverse range

of bioactive molecules making them a rich source of different types of medicines, researches in bioactive substances might result to the discovery of new compounds that could be used to formulate new and more potent antibacterial drugs to overcome the problem of resistance to the currently available antibiotics. Also the importance of proper identification of these medicinal plants and their individual peculiar traits cannot be overstressed, it is vital that proper taxonomy is recorded in order not to confuse the plant in question with closely related species. The aim of this research is to study the antibacterial activity and chemical composition of methanol extract of *Cochlospermum tinctorium* root powder and to determine the chemical composition of the most active methanol extract of *Cochclospermum tinctorium* root powder using GC-MS (Gas chromatography- Mass spectrometry).

Material and Method

Sample Collection

The roots of *Cochlospermum tinctorium* were collected from the rock side in Dambu Gomo, Rafin Zuru District, Zuru Local Government Area of Kebbi State. The samples were packaged in sterile polythene bags and it was transported to the Department of Microbiology Laboratory of Usmanu Danfodiyo University, Sokoto.

Sample Processing and Preparation

Cochlospermum tinctorium roots were washed, air-dried and milled to powder using mortal and pestle and sieved to obtained fine powder and stored at room temperature with plastic packaging until use.

Methanol Extraction of Plant

The method of extraction employed in this research was maceration extraction. The powdered plant material (300g) of the root of *Cochlospermum tinctorium* was extracted with 2000 mL of methanol by subjecting it to maceration at room temperature (35^{o}C) for 24 hours and later filtered with Whatmans filter paper 12. The extract were transferred into an evaporating dish and allowed to dry at 35^{o}C. The percentage (%) yield of methanol extract of *Cochlospermum tinctorium* was calculated as follow:

$$\text{Percentage yield} = \frac{\text{Mass of Extract}}{\text{Mass of Sample}} \times 100$$

Test Bacteria

The test bacteria used in this research were obtained from an ongoing research . The organisms collected from Ten (10) food-borne isolates strains of *Staphylococcus aureus* and *Listeria monocytogene* isolated from onion, cabbage, lettuce and tomato

Antimicrobial Screening of *Cochlospermum tinctorium* against Test Bacteria

Preparation of Extract Concerntrations

In different test tubes One (1 gram) of the extract was weighed and were dissolved in 5 mL of DiMethyl Sulphoxide (DMSO) to obtained concentration of 200 mg/mL. This was the initial concerntration of the extract used to check the antimicrobial activities of the plant. Mueller Hinton agar was used as the growth medium for antibacterial screening [16].

Preparation of Inocula

The stock cultures were sub-culture on nutrient agar and incubated at 37^{o}C for 24 hours. After incubation, a sterile wire loop was used to pick up the colonies of test bacterium and suspended in a test tube containing 10 mL of sterile normal saline. The turbidity of the innocula suspension was adjusted and standadized to that of 0.5 McFarland standard.

Antibacterial Sensitivity

The antibacterial activity of methanol extracts of *Cochlospermum tinctorium* was determined using agar well diffusion method. Sterilized cotton swabs were dipped in the bacterial culture in nutrient broth and then swabbed on the Mueller Hinton plates. Wells of equal size (10.00 mm) were made with the aid of sterile cork borer and the plant extracts were added aseptically into the well. Then the plates were incubated at 37^{0}C and observed for zones of growth inhibition after 24 hours.

Determination of minimum inhibitory concerntration (MIC) of the extracts.

The minimum inhibitory concerntration of the extracts was determined using the broth dilution method in nutrient broth. Normal saline was used to make a turbid suspension of the microbes; the dilution of microorganisms was done continuously in normal saline until the turbidity matched that of the McFarland's standard by visual comparison. Five hundred micro-litres (500µL) of the test organism were aseptically inoculated in each of the four tubes containing the extract in order of increasing dilution (500, 250, 125 and 62.5 mg/mL). Thereafter, the test tubes were incubated at 37^{0}C for 24 hours. After incubation, the test tube with the lowest

concerntration of extracts without visible turbidity was taken to be the minimum inhibition concerntration (MIC) [16]'

Determination of Minimum Bactericidal Concerntration (MBC) of the Extracts.

Sample were taken from the broth with no visible growth in the MIC assay and subculture on freshly prepared nutrient agar and incubated at 37°C for 24 hours. The MBC was taken as the concentration of the extracts that did not show any visible growth on a new set of agar plates [17].

Thin-Layer Chromatography Analysis of *Cochlospermum tinctorium* Methanolic Extracts

The TLC plate used for the separation was made with silica gel on aluminium (TLC silica gel 60_{254} 20.0cm × 20.0cm). Thin layer chromatography was carried out using TLC pre-coated plate (TLC silica gel 60 F_{254}) by conventional one dimensional ascending technique. Spotting was done using capillary tube and developed chromatography tank at room temperature. TLC separations were conducted using 100% methanol as the solvent system. The positions of the different compounds were observed on TLC plates. They were placed under UV light which showed the presence of different spots on the chromatogram. The movement of the active compound was expressed by its retention factor (R_f), values were calculated for different samples.

$$R_f = \frac{\text{Distance traveled by the solute}}{\text{Distance moved by solvent front}}$$

Column chromatography (CC) analysis of *Cochlospermum tinctorium* methanolic extracts

A glass tube with a circle large inlet and a small outlet with a plug or tap known as column was cleaned and dried. Cotton pad was placed at the bottom of the column. The column was packed with 107 gram of column grade silica (60 grade, Mesh size was 70-230um). The silica was added to the column by;

Elution: The elution was done using methanol, and ethyl acetate in different ratio as given below:

Solvent system	Ratio
Methanol and Ethyl acetate	80:20
Methanol and Ethyl acetate	60:40
Methanol and Ethyl acetate	0:100
Methanol and Ethyl acetate	100:0

All the fractions were collected separately and subjected to antimicrobial screening.

Antibacterial Sensitivity of Active Fractions of *Cochlospermum tinctorium*root powder

The antibacterial activity of active fractions of *Cochlospermum tinctorium* root powder was determined by well diffusion method. Sterilized cotton swabs were dipped in the bacterial culture in nutrient broth and then swabbed on the Mueller Hinton plates. Wells of 10.00 mm size were cut on Mueller Hinton agar and the extracts were added into it. Then the plates were incubated at 37^0C and observed for zones of growth inhibition after 24 hours.

Gas Chromatography Mass Spectoscopy (GC-MS) analysis of the active fractions

GC-MS analysis was performed using GC-MS-QP2010 Plus (Shimadzu, Japan) and Gas chromatograph interfaced to a mass spectrometer (GC-MS) instrument employing the following; Column Elite-1 fused silica capillary column (30m x 0.25mm 1D x µl df, composed of 100% Trisil). For GC-MS detection, an electron ionization system with ionization energy of 70eV was used. Helium gas (99.999%) was used as the carrier gas at constant flow rate 1ml/min and an injection volume of 2 µL was employed (Split ratio of 20:0) injector temperature 250^0C; ion-source temperature 200^0C. the oven temperature was programmed from 60.0 (for 0.00 minute) with an increase of 160^0C (Isothermal for 2.00 minutes) ending with a 2.00 minutes isothermal at 280^0C. Mass spectra were taken at 70eV; a scan interval of 0.5s and fragments from 45 to 700Da. Total GC running time was 19 minutes. The relative percentage amount of each component was calculated, by comparing its average peak area to the total areas, Software adopted to handle mass spectra and chromatogram was a turbomass. The detection employed the NIST Ver.2.0 year 2009 library [18].

Identification of components

Interpretation on mass spectrum of GC-MS was done using the database of National Institute of Standard and Technology (NIST) having more than 62,000 patterns. The mass spectrum of the unknown component was compared with the spectrum of the known components stored in the NIST library. The name, molecular weight and structure of the components of the test materials were ascertained.

RESULTS

The percentage yield of the crude extracts (g) obtained from the methanol extracts are presented on Table 1. The result indicates that methanol had the percentage yield of 5.17%.

Table 1: Percentage Yield of Crude Methanol Extract of *Cochlospermum tinctorium* Root Powder

Solvent	Mass of sample (g)	Yield of the extract (g)	Percentage Yield (%w/w)
Methanol	300	15.5	5.17

The result of the thin layer chromatography (TLC) of *Cochlospermum tinctorium* crude methanol extract are presented on Table 2. The solvent system used was 100% methanol and four spots were visible and their Rf values are 0.02, 0.37, 0.44 and 0.80.

Table 2: Thin layer chromatography (TLC) of the Crude Methanolic Extract of *Cochlospermum tinctorium* Root Powder

Solvent system	Spots movement (cm)	Solvent front (cm)	R_f value
Methanol extract	0.2	9.8	0.02
	3.6	9.8	0.37
	4.3	9.8	0.44
	7.8	9.8	0.80

The result of the column chromatography (CC) of *Cochlospermum tinctorium* crude methanol extract are shown on Table 3. The result indicates that ratio (80:20) had the highest number of active fractions of 3, followed by ratio (60:40) having 2, and lastly ratio (100:0) having 1 fraction only.

Table 3: Column Chromatography (CC) of the Crude Methanolic Extract of *Cochlospermum tinctorium* Root Powder

olvent	Solvent ratio	Fractions
Iethanol	80:20	3
	60:40	2
	0:100	0
	100:0	1

The antibacterial activity of the crude methanol extracts of the roots of *Cochlospermum tintorium* against antibiotic resistant *Staphylococcus aureus* and *Listeria monocytogene* (Table 4). The methanol extract reveals maximum zone of inhibition of 22.00 mm against antibiotic resistant

Staphylococcus aureus isolated from tomato and 21.00 mm against *L. monocytogene* R1 at concerntration of 10mg/ml, while the lowest zones of inhibition of 12.00 mm was recorded against *S. aureus* isolated from spring onion and *L. monocytogene*.

Table 4: Antibacterial activity of *Cochlospermum tinctorium* crude methanol extract against the antibiotic resistant *Staphylococcus aureus* and *Listeria monocytogene*

	Concentrations/Zone of inhibition in (mm)				
Test Organisms	**10 mg/mL**	**5 mg/mL**	**2.5 mg/mL**	**Negative Control**	**Positive Control**
S. aureus SP1	19.0±0.6	16.0±0.2	12.0±0.9	0.00	22.0±0.3
S. aureus SP2	20.0±0.9	18.0±0.4	13.0±0.8	0.00	20.0±0.8
S. aureus SP2	19.0±0.5	15.0±0.6	12.0±0.6	0.00	20.0±0.4
S. aureus L	20.0±0.4	16.0±0.1	14.0±0.2	0.00	21.0±0.6
S. aureus T	22.0±0.6	20.0±0.6	17.0±0.4	0.00	24.0±0.6
L. monocytogene R1	21.0±0.5	18.0±0.5	13.0±0.7	0.00	25.0±0.3
L. monocytogene R2	20.0±0.6	18.0±0.3	14.0±0.3	0.00	26.0±0.5
L. monocytogene R3	21.0±0.1	19.0±0.4	14.0±0.5	0.00	26.0±0.4
L. monocytogene R4	19.0±0.4	16.0±0.6	12.0±0.6	0.00	24.0±0.2
L. monocytogene R5	20.0±0.3	15.0±0.6	14.0±0.3	0.00	28.0±0.6

Key: SP = Spring onion, R = Cabbage, L = Lettuce and T = Tomato. The result is presented as mean±SD

The result of the minimum inhibitory concerntration (MIC) of *Cochlospermum tinctorium* crude methanol extract against antibiotic resistant *S. aureus* and *L. monocytogene* are presented on Table 5. It was observed that the *S. aureus* SP1, SP2, and L showed MIC at 2.5mg/mL while *S. aureus* T show MIC at 1.25 mg/mL, the *L. monocytogene* R1, R2, R3, R4 showed MIC at 2.5 mg/mL while R5 showed MIC at 0.625 mg/mL. The minimum inhibitory concerntration of the crude methanol extract was obtained between 2.5-0.625 mg/mL for both *S. aureus* and *L. monocytogene*.

Table 5: Minimum Inhibitory Concerntration (MIC) of *Cochlospermum tinctorium* Crude Methanol Extract Against Antibiotic Resistant *S. aureus* and *L. Monocytogene*

	Concentrations of extracts				
Test Organisms	**10mg/m**	**5mg/ml**	**2.5mg/ml**	**1.25mg/ml**	**0.625mg/ml**
S. aureus SP1	-	-	©	+	+
S. aureus SP2	-	-	©	+	+
S. aureus SP2	-	-	©	+	+
S. aureus L	-	-	©	+	+
S. aureus T	-	-	-	©	+
L. monocytogene R1	-	-	©	+	+
L. monocytogene R2	-	-	©	+	+
L. monocytogene R3	-	-	©	+	+
L. monocytogene R4	-	-	©	+	+
L. monocytogene R5	-	-	-	-	©

Key: SP = Spring onion, R = Cabbage, L = Lettuce and T = Tomato and © = MIC

The result of the minimum bactericidal concerntration (MBC) of *Cochlospermum tinctorium* crude methanol extract against antibiotic resistant *S. aureus* and *L. monocytogene* are presented in Table 6. From the results obtained isolates *S. aureus* SP1, SP2 and L showed MBC at 5 mg/mL while *S. aureus* T showed MBC at 2.5 mg/mL, the *L. monocytogene* R1, R2, R3, R4 showed MIC at 5 mg/mL while R5 showed MBC at 2.5 mg/mL.

Table 6: Minimum bactericidal concerntration (MBC) of *Cochlospermum tinctorium* Crude Methanol Extract Against Antibiotic Resistant *S. aureus* and *L. Monocytogene*

	Concentrations				
Test Organisms	**10mg/m**	**5mg/ml**	**2.5mg/ml**	**1.25mg/ml**	**0.625mg/ml**
S. aureus SP1	-	-	©	+	+
S. aureus SP2	-	-	©	+	+
S. aureus SP2	-	-	©	+	+
S. aureus L	-	-	©	+	+
S. aureus T	-	-	-	©	+
L. monocytogene R1	-	-	©	+	+
L. monocytogene R2	-	-	©	+	+
L. monocytogene R3	-	-	©	+	+
L. monocytogene R4	-	-	©	+	+
L. monocytogene R5	-	-	-	-	©

Key: SP = Spring onion, R = Cabbage, L = Lettuce and T = Tomato, © - MIC

The results for the antibacterial activity of the active methanol extract of *Cochlospermum tinctorium* root powder against antibiotic resistant *S. aureus* and *L. monocytogene* are presented in Table 7. The active methanol extract of *Cochlospermum tinctorium* root powder reveals maximum zone of inhibition 26.00 mm against *S. aureus* L, 20.00 mm against *L. monocytogene* R4 and minimum inhibition of 15.00 mm against *S. aureus* L, 12.00 mm against *L. monocytogene* R2.

Table 7: Antibacterial activity of active methanol fractions of *Cochlospermum tinctorium* root powder against antibiotic resistant *S. aureus* and *L. Monocytogene*

Fraction	**Test organism**	**Zone of Inhibition (mm)**		
F – A	*S. aureus* L	22.0±0.6	26.0±0.5	23.0±0.6
F – B	*S. aureus* L	15.0±0.3	16.0±0.6	16.0±0.2
F – D	*L. monocytogene* R5	14.0±0.8	14.0±0.9	13.0±0.3
F – E	*L. monocytogene* R4	20.0±0.6	19.0±0.4	21.0±0.8
F – F	*L. monocytogene* R2	13.0±0.5	13.0±0.1	12.0±0.4

Key: L = Lettuce, R = Cabbage. The result is presented as mean±SD

The result of the minimum inhibitory concerntration (MIC) of the active methanol fractions of *Cochlospermum tinctorium* root powder against antibiotic resistant *S. aureus* and *L. monocytogene* are presented on Table 8. From the results obtained isolate *S. aureus L* showed MIC at 4.0 mL, *L. monocytogene* R5 showed MIC at 5.0 mL, *L. monocytogene* R2 showed MIC at 3.0 ml and *S. aureus* R showed MIC at 3.0 mL.

Table 8: The minimum inhibitory concerntration (MIC) of the active methanol fractions of *Cochlospermum tinctorium* root powder

Fraction	Test organism	1	2	3	4	5	6	7
F – A	*S. aureus* L	-	-	-	-	+	+	+
	L. monocytogene R5	-	-	-	-	-	+	+
F – E	*L. monocytogene* R2	-	-	-	+	+	+	+
	S. aureus R	-	-	-	+	+	+	+

Key: L= Lettuce, R = Cabbage

The result of the volatile organic compound profile of the active methanol fraction (A) of *Cochlospermum tinctorium* root powder tested against antibiotic resistant *Staphylococcus aureus* and *Listeria monocytogene* are presented on Table 9a. The chromatogram shows 23 peaks (compounds) in fraction A of which the highest peak intensity was observed at peak 3 (3-Tetradecanone- 20.99%) and the lowest at peak 15 (5-Hexyn-1-ol- 0.22%).

Table 9a: Volatile organic compound profile of the active methanol fraction A of *Cochlospermum tinctorium* root powder tested against antibiotic resistant *S. aureus* and *L. monocytogene*

RT^{-1}	Compound	Molecular formular	Peak Area Normalised (%)
4.673	Tris (trimethylsilyl) amine	$C_9H_{27}NSi_3$	9.60
9.702	Undecane, 3-methylene-	$C_{12}H_{24}$	11.36
9.793	3-Tetradecanone	$C_{14}H_{28}O$	20.99
10.007	Undecyl acetate	$C_{13}H_{26}O_2$	7.82
10.926	1-Tridecene	$C_{13}H_{26}$	1.16
11.231	2-Heptanone, 4-methyl-	$C_8H_{16}O$	0.45
11.950	Saccharin	$C_7H_5NO_3S$	0.23
12.285	Heptanoic acid, 2-ethyl-, methyl ester	$C_{10}H_{20}O_2$	1.50
12.359	Tridecane, 3-methylene-	$C_{14}H_{28}$	1.80
12.427	3-Hexadecanone	$C_{16}H_{32}O$	2.05
12.584	1-Hexadecanol, acetate	$C_{18}H_{36}O_2$	20.82
12.947	Butanoic acid, 3-methyl-, 3,7-dimethyl-6-octenyl ester	$C_{15}H_{28}O_2$	0.99
13.022	3,3-Dimethyl-4-heptanol	$C_9H_{20}O$	0.68
13.436	(R)-(-)-(Z)-14-Methyl-8-hexadecen-1-ol	$C_{17}H_{34}O$	0.80
13.819	5-Hexyn-1-ol	$C_6H_{10}O$	0.22
14.311	Lauric acid, isopentyl ester	$C_{17}H_{34}O_2$	10.05
14.537	Heptanal n-Heptaldehyde	$C_7H_{14}O$	1.02
14.792	1-Hexadecanol, acetate	$C_{18}H_{36}O_2$	3.09
14.870	Stearic acid, ethyl ester	$C_{20}H_{40}O_2$	0.77
15.300	(R)-(-)-(Z)-14-Methyl-8-hexadecen-1-ol	$C_{17}H_{34}O$	0.76
16.010	Oleyl alcohol, trifluoroacetate	$C_{20}H_{35}F_3O_2$	0.60
16.318	Tridecane, 3-methylene-	$C_{12}H_{24}$	1.67
17.077	Oleyl alcohol, trifluoroacetat	$C_{20}H_{35}F_3O_2$	1.58

The result of the volatile organic compound profile of the active methanol fraction (E) of *Cochlospermum tinctorium* root powder tested against antibiotic resistant *Staphylococcus aureus* and *Listeria monocytogene* are presented on Table 9 b. The chromatogram shows 11 peaks (compounds) in fraction E of which the highest peak intensity was observed at peak 11 (i-Propyl 9,12-octadecenadienoate - 69.12%) and the lowest at peak 3 (Silane, trimethyl(2-phenylethoxy)- 0.26%). Other compounds identified in fraction E include; Cyclotrisiloxane,hexamethyl-, 4-Isothiazolecarboxamide, .Omega.-Phenylacetic acid, Benzeneethanol, 4-hydroxy-, Pyrazolo[5,1-c]-as-triazine-, 1,2-Butadiene,1,1,4-triphenyl-3-trimethylsilyl-4-trimethylsilyloxy-, Diethyl Phthalate1, l-(+)-Ascorbic acid 2,6-dihexadecanoate, Heptanoic acid, 2-ethyl-.

Table 4.9b: Volatile organic compound profile of the active methanol fraction (E) of *Cochlospermum tinctorium* root powder tested against antibiotic resistant *S. aureus* and *L. monocytogene*

RT^{-1}	Compound	Molecular Formular	Peak Area Normalised (%)
5.014	Cyclotrisiloxane, hexamethyl-	$C_6H_{18}O_3Si_3$	2.31
6.071	4-Isothiazolecarboxamide	$C_4H_4N_2OS$	0.59
6.490	Silane, trimethyl(2-phenylethoxy)-	$C_{11}H_{18}OSi$	0.26
6.670	.Omega.-Phenylacetic acid	$C_8H_8O_2$	0.38
8.654	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	0.64
10.042	Pyrazolo[5,1-c]-as-triazine-	$C_7H_6N_4O_2$	0.58
10.234	1,2-Butadiene,1,1,4-triphenyl-3-trimethylsilyl-4-trimethylsilyloxy-	$C_{28}H_{34}OSi_2$	0.36
10.440	Diethyl Phthalate 1	$C_{12}H_{14}O_4$	2.83
13.666	1-(+)-Ascorbic acid 2,6-dihexadecanoate	$C_{38}H_{68}O_8$	22.02
13.934	Heptanoic acid, 2-ethyl-	$C_9H_{18}O_2$	0.92
15.064	i-Propyl 9,12-octadecenadienoate	$C_{21}H_{38}O_2$	69.12

Discussions

The results from this finding revealed that the methanol extracts of *Cochlospermum tinctorium* root posses antibacterial activity against *Staphylococcus aureus* and *Listeria monocytogene* isolated from vegetable foods. This study also suggests that the *Cochlospermum tinctorium* root could be useful in prevention of food borne diseases associated with onion, cabbage, lettuce and tomato. The result of methanol extraction yield 5.17% extracts. This proves that the root of *C. Tinctorium* possess high potential source for the phyto-compounds. This is similar with the finding of Ibrahim *et al.* [19] reported that the methanol extraction of *Ceiba pentandra* yield 5% of the extracts. The results of thin layer chromatography revealed that the component which shows less R_f value in a less polar solvent has high polarity and a high R_f values in less polar solvents shows that the compound is less polar [20].

The results of the antibacterial studies showed that the methanol extract of *C. tinctorium* was active against the various test bacteria at different concentrations tested. However, both the bacteria were found to be susceptible to the antimicrobial activity of the extract. The reason for high antbacterial activity could be attributed to fact that *S. aureus* and *L. monocytogene* are gram-positive bacteria whose outer peptidoglyan layer is not an effective permeability barrier.

Similarly, flavonoids are reported to have antibacterial activity [21], thus, they may be partly responsible for the antimicrobial activity of the extract. The minimum inhibitory concerntration of the crude methanol extract was obtained between 2.5 mg - 0.625 mg for both *S. aureus* and *L. monocytogene*. This is similar with previous studies of Aliyu *et al.* [22] obtained MIC 2.09 mg/ml against *S. aureus* in the phytochemical and antibacterial properties of leaf extract of *Stereospermum kunthianum* (Bignoniaceae), and Kim *et al.* [23] obtained 2.0 mg/ml against *L. monocytogene* in the antibacterial and antioxidant activity of *Saposhnikovia divaricata*, *Peucedanum japonicum* and *Glehnia littoralis*. The MBC of the crude methanol extract showed that the extract have bactericidal activity to *L. monocytogene* and *S. aureus* between 5.0 mg - 2.5 mg. Previous studies by Okemo *et al.* [24] suggested that at higher concerntration the organisms would be killed at a faster rate. The active methanol extract of *Cochlospermum tinctorium* root powder reveals maximum zone of inhibition 26.00 mm against *S. Aureus* L, 21.00 mm against *L. Monocytogene* R4 and minimum zone of inhibition 15.00 mm against *S. Aureus* L, 12.00 mm against *L. Monocytogene* R2. This study is in close agreement with a previous studies of Arora *et al.* [25] that obtained 22.30 mm against *L. Monocytogene* in the antibacterial activity of seed, pomace and leaf extract of *Hippophae rhamnoides L*. (sea buckthorn).

The GC-MS analysis of the active fractions showed the existence of various bioactive compounds with different chemical structures. The major compound in both fraction (A and E) are: 1-(+)-Ascorbic acid 2,6-dihexadecanoate, Diethyl phthalate, Undecyl acetate, 3-tetradecanone, 3-hexadecanone. Previous studies reported that 1-(+)-Ascorbic acid 2,6-dihexadecanoate which is identified in the aqeous extract of *Indigofera tinctoria* possess an antioxidant, anti-inflammatory and anti-nociceptive properties [26]. Diethyl phthalate was identified in the methanol extract of the flower of *Quisqualis indica* plant extract and it was found effective against *E.coli* and least effective against *S. pnemoniae, S. aureus* [27][28]. Undecyl acetate was identified in the essential oil of *C. planchonii* and was effective against diarrhoea and some other infections [29]. 3-tetradecanone, 3-hexadecanone were identified in the essential oil of whole tubercle of *C. tinctorium* and was found to posess anti plasmodial properties [30].

Conclusion

From the above research it can be concluded that *Cochlospermum tinctorium* root powder has immense potential to be used in the area of pharmacology as it possess antimicrobial activity against the antibiotic resistant food-borne pathogens, thus could be exploited as alternative

antimicrobial drugs for the treatment of diseases caused by those pathogens. Due to the presence of various compounds that are essential for good health, it can also be used to improve the health status of the mankind. The volatile organic compound profiling of the major compounds showed that they possess antimicrobial, anti-inflammatory and antinociceptive properties.

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