Original Research Article

Phytochemical and Antibacterial profile of *Moringa oleifera lam* seed extracts on some wound and enteric bacterial pathogens

ABSTRACT

The seeds of *Moringa oleifera* were studied in this research to determine the phytochemicals present and assess the antibacterial activities of the seed extracts against some wound and enteric bacterial pathogens. The extracts of *Moringa oleifera* seeds were obtained. The phytochemical constituents of the extracts were evaluated, while the antibacterial efficacy of extracts (FMSE, FMSA and DMSE, DMSA) were tested against five bacterial organisms namely; *Pseudomonas aeruginosa, Escherichia coli*, *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Salmonella typhi* isolated from both wound and faeces of typhoid fever patients using agar diffusion technique (punch method). Two-fold tube dilution method was used for the Determination of the Minimum Inhibitory Concentration (MIC). The Minimum Bactericidal Concentration (MBC) was also ascertained. Phytochemical analysis of the extracts revealed the presence of saponin, flavonoids, alkaloids and tannins. Both the aqueous and ethanolic extracts exhibited antibacterial effects against all the test organisms. DMSE at 500mg/ml had the inhibition zone of *S. aureus* as the highest (38.00^{a}) and that of *E. coli* and *S. typhi* as the lowest (10.00^{b}), while FMSE had the highest zone of inhibition to be 20.00^{b} against *S. typhi* and *P. aeruginosa* and the lowest zone of 14.00^{b} against *E. coli*. This study suggests that seed extracts of *Moringa oleifera* possess antibacterial properties. Ethanolic extracts were effective than aqueous extracts, meaning that the potency is solvent dependent. Dried seed extracts were more effective than fresh extracts. Inhibition of Gram-positive and Gram-negative organisms portrays this plant as a potential source of broad-spectrum antibiotics. The findings from this work suggest further purification of the constituents of the plant for the development of novel antibiotics.

Keywords: Phytochemical, Antibacterial, Typhoid fever, Extracts, Plant.

1.0. INTRODUCTION

The existence of infectious diseases in this terrestrial ball is as old as man. The morbidity and mortality rates of these plagues are as embarrassing as shocking especially in developing countries. *Homo sapiens* in a bid to contend, contain and eradicate the myriad of sicknesses that pose a great challenge to her health and survival has resorted to the use of various medicinal plants found in her local environment [1].

Medicinal plants and plants in general have been of immense importance to man. The medicinal use of herbs and shrubs in the treatment of various diseases both physiologically and otherwise is an important break-through in the pharmacognosy and is a great contribution to the development of modern pharmacotherapeutics in Africa. In some parts of Africa, people depend somehow on medicinal plants for the treatment of their diseases [2].

The practice of folklore medicine is widely spread all over the world [3]. Medical plant has been defined by The world health organization (WHO) consultative group define Medicinal plant as one which has a part of more parts that can be used for the treatment of diseases or which can be used for the production of synthetic drugs [1]. Prior to the discovery of synthetic drugs, the practice of medicine relied extensively of plant parts [2].

One of the medicinal plants that has enjoyed wide use in folk medicine is *Moringa. Moringa* native to Arabia, Africa, and belongs to the family, Moringaceae and has about 13 species of varying sizes [4, 5].

The Moringa tree serves as vegetable, spice, medicine, and is also a source of cosmetic oil [6]. Moringa grows quickly in many types of environment. The plant is edible for human and farm animals. It is rich in different nutrients [7] and has been employed in the management and prevention of about 300 diseases [8]. Almost all the parts, have been used for the treatment of various ailments in traditional medicine [9]. This plant provides lots of phytochemicals and its medicinal value is attributed to these phtochemicals [10].

The issue of drug resistance has become a serious challenge in the present day medical practice, and effort is now geared towards the production of new and potent antimicrobials. Consequent upon the afore-mentioned properties of this plant, and its use in traditional medicine, this research thus intends to determine the phytochemicals and assess the antibacterial property of aqueous and ethanol seed extracts of *Moringa oleifera* against wound and enteric bacterial pathogens. This will provide alternative therapy for the management wound and typhoid fever infections which have become resistant to most synthetic antibiotics as well as authenticate the antibacterial claims of this plant.

2.0. MATERIALS AND METHODS

Collection of Plant Samples

The seeds of *Moringa oleifera* were collected and authenticated at the Department of Plant Science and Biotechnology Imo State University, Owerri. After drying the seeds for two weeks at room temperature, they were grinded, packaged, correctly labelled, and stored for future use. Another set of seeds (fresh) were collected, ground and used immediately without drying.

Extraction

Ninety eight percent (98%) ethanol and distilled water were used for the extraction. The grinded seeds (both fresh and dried) were weighd (50 grams each) and dissolved in 500ml of the solvents. These were allowed to stay ten days while being mixed intermittently. Afterwards, the mixtures were filtered and the ethanol extracts concentrated with the aid of a Rotary evaporator (R100). Hot air oven was then used in the concentration of aqueous extract overnight at 40^{o}C [11]. The concentrated extracts were recovered in sterile bottles and labeled accordingly: FMSE (Fresh *moringa* seed ethanol extract), DMSE (Dried *moringa* seed ethanol extract), FMSDW (Fresh *moringa* seed distilled water extract), DMSDW (Dried *moringa* seed distilled water extract).

Screening for Phytochemicals

The method described by Lajubutu *et al.*, [12] was used for this. Alkaloids, Tannins, Saponin, Akaloids and Flavonoids were tested for in the extracts [13].

Test Bacteria

The bacteria used for this research were *Pseudomonas aeruginosa, Streptococcus pyogenes, Staphylococcus aureus, and Escherichia coli.* These were isolated from wound swabs obtained from accident and maternity wards of Abia State University Teaching Hospital Aba, Abia State, Nigeria. The swabs were collected after submitting a letter to the chief medical Director and obtaining the approval of the medical and ethics committee of the hospital. *Salmonella typhi* was isolated from stool samples. Isolates were identified by Cultural, morphological, and biochemical characteristics. *S. typhi* was biochemically differentiated from other *Salmonellae* by being citrate negative, not producing gas and forming only small amount of hydrogen sulphide. Serologically it was differentiated by the presence of vi antigen [14].

Antibacterial Assay

The method described by Osadebe and Ukwueze, [15] was adopted for this. Basically, it involved the agar gel diffusion technique (punch method). 0.1ml of the isolates broth culture was aseptically inoculated onto Nutrient Agar (NA) plates. With the aid of a sterile cork borer, Wells of 5.0mm diameter each was made in seven places on the plates. Two out of the seven wells were used as negative control (contained distilled water), while one of the wells was used as a positive control (harboured ciprofloxacin). For the antibacterial assay, various concentrations (500mg/ml, 250mg/ml, 125mg/ml and 63mg/ml) were used and these were obtained through double dilution. 0.1ml of the four different concentrations were used to fill the remaining wells. Same volumes of the control samples was used to fill the control wells. To give room for pre-diffusion to occur, the plates were left at room temperature for 40 minutes [16]. Afterwards, they were incubated at 37^{o}C for 24hours. The experiment was carried out in triplicates and the mean values obtained after measuring the zones of inhibition produced against each bacterium were taken as antibacterial activity [17, 18].

Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)

The macro broth dilution techniques were used for the determination of the extracts' MIC and MBC [19]. The four different concentrations obtained through Double dilution was also applied here. The test organisms (in standard suspensions) were inoculated into the tubes containing the different dilutions (500, 250, 125 and 63mg/ml) of the extracts. These were incubated at 37^{o}c for 24 hours. The MICs were reported as the least concentration with no turbidity. To determine the MBC, a loopful of the broths with no turbidity during MIC, was collected and sub-cultured on fresh Nutrient Agar. These were incubated for 24 hours at 37^{o}c. MBC was noted as the least concentration at which no visible growth was observed.

3.0 RESULTS

The results obtained in this research is shown in tables. Table 1 shows the phytochemical constituents of the fresh and dried seed and leaf of *Moringa oleifera.*

Table 1: Phytochemical Constituents of *Moringa oleifera* seeds

MO	**Phytochemical Components**			
Sample	Alkaloids	Saponin	Flavonoid	Tannins
FMSE	+	+	+	+
DMSE	+	+	+	+
FMSDW	+	+	+	+
DMSDW	+	+	+	+

Table 1 above shows the Phytochemical analysis results of the four extracts:- FMSE, DMSE, FMSDW and DMSDW. From the table, the four phytochemical components tested for viz, alkaloids, saponin, flavonoid and tannins were found to be present in each of the extracts. Their presence were indicated with a (+) sign.

KEY:

FMSE- Fresh *moringa* seed ethanol extract
DMSE- Dried *moringa* seed ethanol extract
FMSDW- Fresh *moringa* seed distilled water extract
DMSDW- Dried *moringa* seed distilled water extract
+ = present
- = Absent.

Table 2: The inhibition zones of fresh *moringa* seed ethanol extract (FMSE) on the test organisms.

Test Organism	Different Concentrations of FMSE				Controls		
					Negative		Positive
	500mg/ ml	250mg/ ml	125mg/ ml	63mg/ ml	Distilled Water	Ethanol	Ciproxin
S. aureus	18mm	14mm	0 mm	0 mm	0 mm	0 mm	30mm
S .pyogenes	18mm	0 mm	0 mm	0 mm	0 mm	0 mm	38mm
E. coli	14mm	0 mm	0 mm	0 mm	0 mm	0 mm	20mm
S. typhi	20mm	0 mm	0 mm	0 mm	0 mm	0 mm	41mm
P. aeruginosa	20mm	0 mm	0 mm	0 mm	0 mm	0 mm	30mm

The pattern and zones of inhibition of fresh *Moringa* seed ethanol extract (FMSE) is shown in table 2 above. At the concentration of 500mg/ml FMSE inhibited the growth of all the test organisms. The highest zone of inhibition was recorded against *S. typhi* and *P. aeruginosa* with zone diameters of 20mm respectively, while the least was recorded against *E. coli* with a zone diameter of 14mm. At the concentration of 250mg/ml the extract also inhibited the growth of *S. aureus* with a zone diameter of 14mm. At other concentrations no inhibition was produced against any of the test organisms. The two negative controls - distilled water and ethanol did not display

inhibitory effect against any of the test organisms. The positive control - ciproxin inhibited the growth of all the test organisms.

Table 3: The diameter of zone of inhibition of dried *moringa* seed ethanol extract (DMSE) on the test organisms.

Test **Organism**	DMSE Concentrations				Controls		
					Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	38mm	14mm	0 mm	0 mm	0 mm	0 mm	40mm
S. pyogenes	15mm	0 mm	0 mm	0 mm	0 mm	0 mm	30mm
E. coli	10mm	0 mm	0 mm	0 mm	0 mm	0 mm	25mm
S. typhi	10mm	0 mm	0 mm	0 mm	0 mm	0 mm	40mm
P.aeruginosa	15mm	0 mm	0 mm	0 mm	0 mm	0 mm	30mm

Table 3 above shows the zone of inhibition produced by DMSE extract. This extract showed inhibitory effect against all the test organisms at the concentration of 500mg/ml. The most inhibited organism is *S. aureus* with a zone diameter of 38mm, while the least is *E. coli* and *S. typhi* with zone diameters of 10mm respectively. DMSE extract also inhibited the growth of *S. aureus* at the concentration of 250mg/ml producing a zone diameter of 14mm. At other concentrations DMSE did not inhibit any of the test bacteria. The negative controls displayed no inhibitory effect against any of the test organisms, whereas the positive control inhibited the growth of all the test organisms with different zone diameters of inhibition.

Table 4: The diameter of zone of inhibition of fresh *Moringa* seed distilled water extract (FMSDW) on the test organisms.

Test **Organism**	FMSDW Concentrations				Controls Negative		Positive
	500mg/ ml	**250mg/ ml**	**125mg/ ml**	**63mg/ ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	0mm	0 mm	0 mm	0 mm	0 mm	0 mm	20mm
S. pyogenes	6mm	0 mm	0 mm	0 mm	0 mm	0 mm	30mm
E. coli	0mm	0 mm	0 mm	0 mm	0 mm	0 mm	26mm
S. typhi	10mm	0 mm	0 mm	0 mm	0 mm	0 mm	35mm
P.aerugino sa	0mm	0 mm	0 mm	0 mm	0 mm	0 mm	36mm

The inhibitory effect of FMSDW on *S. pyogenes* and *S. typhi* was only shown at the concentration of 500mg/ml with zone diameters of 6mm and 10mm respectively. It was unable to inhibit the growth of the organisms at other concentrations. Distilled water and ethanol exhibited no inhibitory effect against the test organisms. Ciproxin on the other hand inhibited the growth of all the test organisms producing different zone diameters of inhibition.

Table 5: The diameter of zone of inhibition of dried *Moringa* seed distilled water extract (DMSDW) on the test organisms.

Test Organism	DMSDW Concentrations				Controls Negative		Positive
	500mg/ ml	**250mg/ ml**	**125mg/ ml**	**63mg/ ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	26mm	0 mm	0 mm	0 mm	0 mm	0 mm	32mm
S. pyogenes	12mm	0 mm	0 mm	0 mm	0 mm	0 mm	26mm
E. coli	10mm	0 mm	0 mm	0 mm	0 mm	0 mm	18mm
S. typhi	14mm	0 mm	0 mm	0 mm	0 mm	0 mm	30mm
P. aeruginosa	20mm	0 mm	0 mm	0 mm	0 mm	0 mm	32mm

DMSDW exhibited inhibitory effect against all the test organisms at the concentration of 500mg/ml. The most inhibited organism is *S. aureus* with a zone diameter of 26mm, while the least is *E. coli* with a zone diameter of 10mm. Just like the negative controls, it did not at other concentrations, inhibit the growth of the test bacteria. The positive control however inhibited all the test bacteria

Table 6: The Fresh *moringa* seed ethanol extract (FMSE) Minimum inhibitory concentrations (MIC)

Test Organism	*FMSE Concentrations*				*Controls*		
					Negative		*Positive*
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	-	-	-	+	+	+	-
S. pyogenes	-	-	+	+	+	+	-
E. coli	-	-	+	+	+	+	-
S. typhi	-	-	-	+	+	+	-
P. aeruginosa	-	-	-	+	+	+	-

- = Inhibition (no growth),
+ = No inhibition (growth).

From the table above, FMSE inhibited the growth of *S. aureus, S. typhi* and *P. aeruginosa* at the concentrations of 500mg/ml, 250mg/ml and 125mg/ml respectively. At the concentration of 63mg/ml no inhibition was produced against these organisms. The MIC of FMSE for *S. aureus, S. typhi* and *P. aeruginosa* is 125mg/ml. Inhibition of *S. pyogenes* and *E. coli* by the extract was reported at the concentrations of 500mg/ml and 250mg/ml respectively. It failed to inhibit the growth of these organisms at other concentrations. Therefore, the MIC of the extract for *S. pyogenes* and *E. coli* is 250mg/ml. Distilled water and ethanol did not exhibit any inhibitory. On the other hand, the growth of all the test organisms was inhibited by ciprofloxacin.

Table 7: Fresh *moringa* seed ethanol extract (FMSE) Minimum Bactericidal Concentration (MBC)

Test Organism	*FMSE Concentrations*				*Controls*		
					Negative		*Positive*
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	-	-	+	+	+	+	-
S. pyogenes	-	-	+	+	+	+	-
E. coli	-	-	+	+	+	+	-
S. typhi	-	-	+	+	+	+	-
P. aeruginosa	-	-	+	+	+	+	-

As depicted in the above table FMSE exhibited bactericidal effect on all the test organisms at the concentrations of 500mg/ml and 250mg/ml. Thus, the MBC of the extract for *E. coli, S. pyogenes, S. aureus, S. typhi* and *P. aeruginosa* is 250mg/ml.

The positive control exhibited bactericidal effect against all the test organisms, while the negative control did not. From the table above, the inhibitory action of FMSE against *S. aureus, S. typhi* and *P. aeruginosa* at the concentration of 125mg/ml was bacteriostatic in nature.

Table 8: Dried *moringa* seed ethanol extract (DMSE) Minimum Inhibitory Concentration (MIC)

Test Organism	DMSE Concentrations				Controls		
					Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	-	-	+	+	+	+	-
S. pyogenes	-	+	+	+	+	+	-
E. coli	-	+	+	+	+	+	-
S. typhi	-	+	+	+	+	+	-
P.aeruginosa	-	+	+	+	+	+	-

As shown in the table above DMSE inhibited the growth of *S. aureus* at the concentrations of 500mg/ml and 250mg/ml respectively. However, no inhibitory action was shown at other concentrations. The MIC of the extract for *S. aureus* is 250mg/ml. At the concentration of 500mg/ml, DMSE exhibited inhibitory effect against *P. aeruginosa, E.coli, S. pyogenes,* and *S. typhi* and No inhibitory action was produced by the extract against these organisms at other concentrations. The MIC of the extract for these test organisms is 500mg/ml. Whereas the negative controls did not inhibit the growth of any of the bacteria, the positive control inhibited all of them.

Table 9: Dried *moringa* seed ethanol extract (DMSE) Minimum bactericidal concentration (MBC)

Test Organism	DMSE Concentrations				Controls		
					Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	-	-	+	+	+	+	-
S. pyogenes	+	+	+	+	+	+	-
E. coli	-	+	+	+	+	+	-
S. typhi	-	+	+	+	+	+	-
P. eruginosa	+	+	+	+	+	+	-

Bactericidal effect was produced by DMSE against *S. aureus* only at the concentrations of 500mg/ml and 250mg/ml. The MBC of the extract for *S. aureus* is 250mg/ml. No bactericidal effect was exhibited by the extract against *S. pyogenes* and *P. aeruginosa* at all the concentrations. At the concentration of 500mg/ml, DMSE showed bactericidal effect against *E. coli* and *S. typhi.* Thus, the MBC of the

extract for these organisms is 500mg/ml. The positive control produced bactericidal effect against all the test organisms, while the negative controls did not show bactericidal effect against any of the test organisms. From the table above, the inhibitory effect of DMSE on *S. pyogenes* and *P. aerugonosa* at the concentration of 500mg/ml was bacteriostatic in nature.

Table 10: Fresh *moringa* seed distilled water extract (FMSDW) Minimum Inhibitory Concentration (MIC)

Test Organism	FMSDW Concentrations				Controls		
					Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	+	+	+	+	+	+	-
S. pyogenes	-	+	+	+	+	+	-
E. coli	+	+	+	+	+	+	-
S. typhi	-	+	+	+	+	+	-
P. aeruginosa	+	+	+	+	+	+	-

In the table above, FMSDW did not exhibit any inhibitory effect against *P. aeruginosa, E. coli,* and *S. aureus,* at all the concentrations. Unlike the positive control, the negative controls also were unable to inhibit the growth of these organisms. At the concentration of 500mg/ml, FMSDW inhibited the growth of *S. pyogenes* and *S. typhi,* but failed to inhibit them at other concentrations. The positive control inhibited the growth of these organisms, while the negative controls did not. The MIC of the extract for *S. pyogenes* and *S. typh*i is 500mg/ml.

Table 11: Fresh *moringa* seed distilled water extract (FMSDW) Minimum Bactericidal Concentration (MBC)

Test Organism	FMSDW Concentrations				Controls		
					Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	+	+	+	+	+	+	-
S. pyogenes	+	+	+	+	+	+	-

E. coli	+	+	+	+	+	+	-
S. typhi	+	+	+	+	+	+	-
P. aeruginosa	+	+	+	+	+	+	-

As shown in the table above, FMSDW did not exhibit bactericidal effect against any of the test organisms. This was the same for the negative controls. On the other hand, bactericidal effect was exhibited by the positive control against all the test organisms. From table above, the inhibitory effect produced by the extract against *S. pyogenes* and *S. typhi* at the concentration of 500mg/ml was bacteriostatic.

Table 12: Dried *moringa* seed distilled water extract (DMSDW) Minimum Inhibitory Concentration (MIC) of on the test organisms.

Test Organism	DMSDW Concentrations				Controls Negative		Positive
	500mg/ml	**250mg/ml**	**125mg/ml**	**63mg/ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	-	+	+	+	+	+	-
S. pyogenes	-	+	+	+	+	+	-
E. coli	-	+	+	+	+	+	-
S. typhi	-	+	+	+	+	+	-
P. aeruginosa	-	+	+	+	+	+	-

At the concentration of 500mg/ml, DMSDW inhibited the growth of the five test organism, but did not show any inhibition at other concentrations. Distilled water and ethanol did not show any inhibition against the test organisms, while ciproxin inhibited the growth of all the bacterial organisms. The MIC of DMSDW for the test organisms is 500mg/ml.

Table 13: dried *moringa* seed distilled water extract (DMSDW) Minimum Bactericidal Concentration (MBC)

Test Organism	DMSDW Concentrations				Controls		
					Negative		Positive
	500mg/ Ml	**250mg/ Ml**	**125mg/ Ml**	**63mg/ ml**	**Distilled Water**	**Ethanol**	**Ciproxin**
S. aureus	+	+	+	+	+	+	-
S. pyogenes	+	+	+	+	+	+	-
E. coli	+	+	+	+	+	+	-
S. typhi	+	+	+	+	+	+	-
P. aeruginosa	+	+	+	+	+	+	-

Neither DMSDW nor the negative controls exhibited any bactericidal effect against any of the test organisms. Bactericidal effect was shown by the positive control against each of the test organisms. From the table above, the inhibitory action of DMSDW against *S. aureus*, *P. aeruginosa*, *S. pyogenes*, *S. typhi*, and *E. coli* at the concentration of 500mg/ml was bacteriostatic in nature.

4.0. DISCUSSION

Undoubtedly medicinal plants have been of immense importance to man. Sofowora [20] stated that medicinal use of herbs and shrubs in the treatment of so many diseases both physiological and otherwise is an important breakthrough in pharmacognosy and is a great contribution to the development of modern pharmacotherapeutics in Africa. This forms the basis of this research.

The phytochemicals: tannins, saponins, alkaloids, flavonoids, have been reported to be present in higher plants by Kaufman *et al.*, [21]. The phytochemical analysis of the extracts showed that flavonoids, alkaloids, saponins, tannins are the constituents which agrees with this report. These phytochemicals confer antibacterial potentials to any plant in which they are found. These compounds were reported by Kaufman *et al.*, [21] and Dutta [22] to be an indication of the potential medicinal value of the plants in which they appear.

The result from the phytochemical analysis of the ethanolic extract of *Moringa* corroborates with the earlier findings of Bukar *et al.*, [23]. Although, alkaloids and tannins were not reported by Bukar *et al.*, [23] but were found in this work. This may be responsible for the higher rate of inhibition recorded in this work. Farooq *et al.*, [24] reported that variation in phytochemicals and their concentrations could be attributed to their different habitats. on the other hand, Walter and Nowacki [25] attributed the production of phytochemicals to be as a result of plant responses to threats.

It has been reported that *Moringa* also contains pterygospermin, an antibactericidal and antifungal agent [26]. Other components that possess antibacterial properties have also been reported [27, 28]. This study revealed that the organisms were sensitive to both extracts and this agrees with the reports by Aktar *et al.*, [29] and Foidl *et al.*, [30]. This work also showed that the two ethanolic extracts (FMSE and DMSE) inhibited the growths of *S. pyogenes, S. typhi, S. aureus, E. coli* and *P. aeruginosa* and this is in agreement with the report by Nepolean *et al.*, [31].

In general, the aqueous extracts are less potent than the ethanol seed extracts of *M. oleifera*. Dutta [22] reported that different solvents dissolve different active ingredients from the same plant and this is presumed to have direct bearing to the type of microorganism affected. It is likely that the active constituents of the plants where better extracted with ethanol than with water, suggesting that ethanol is a prefeered

solvent. This observation is in tandem with the reports of Ogunjobi and Nnadozie [32] and Ezeifeka *et al.*, [33] which showed higher antimicrobial activities of ethanol extracts of plant parts than the aqueous extracts. Although, it contradicts the report by Ndubueze *et al.*, [34] in which there was no difference between ethanolic and aqueous extracts of *Gongronema latifolium.*

Contrary to previous studies, comparison of the potency of both seeds was done. It was shown that dried *Moringa* seeds produced more inhibitory activity than the fresh seeds. As shown in table 3 above, DMSE inhibited the growth of *S. aureus* with a zone diameter of 38mm making it the most sensitive organism in this work, as against the highest zone diameter of 20mm produced by FMSE against *S. typhi* and *P. aeruginosa* respectively in table 2. This shows that the dried seed is more effective than the fresh seed. This may be due to the reduction in water content of the dry seed thereby making the antibacterial agent to be more concentrated.

Authors like Olsen, [35]; Madsen *et al*., [36]; Kawo, [37], have reported the antibacterial property of *M. oleifera* seed. These antimicrobial activities have been attributed to the phytochemical constituents, especially, the activity of a polypeptide known as 4(d-L-rhamnosyloxy) benzyl-isothiocyanate [38, 39]. The peptide may act directly on microorganisms and result in growth inhibition by disrupting cell membrane synthesis or synthesis of essential enzymes [40, 41].

Inhibition of the test organisms by aqueous extracts was also recorded. In fact the extract inhibited at least two of the test organisms. DMSDW showed inhibitory action against *S. aureus, P. aeruginosa, S. pyogenes, S. typhi* and *E. coli*, and. This is in agreement with a similar study carried out by Saadabi and Abu [42]. The inhibitory action produced by each of the four extracts used in this research agrees with the report of [9].

In this study, all the extracts inhibited the growth of *P. aeruginosa* and the commonest etiologic agent of enteric fever *Salmonella typhi*. Brooks *et al.*, [43], reported that enteric fever had mortality rate of 10-15% in developing countries of which Nigeria is one. The successful inhibition of these organisms by the extract is a welcome development, especially when considering the level of multi-resistance these bacteria have developed against conventional antibiotics over the years. This shows that the extracts can be used as therapy for the treatment of typhoid fever and other infections caused by these organisms.

CONCLUSION

The findings from this study has revealed the antibacterial properties of seed extracts of *M. oleifera* which can be explored. It also showed that the dried seed is more effective than the fresh seed. Both Gram-positive (*S. aureus, S. pyogenes)* and Gram-negative (*E. coli, S. typhi and P. aeruginosa*) bacteria were inhibited by the plant extract which implies that it is a potential source for the production of broad spectrum antibiotics, which can be used to treat some of the infections that have constituted a nightmare in the present day medical practice, owing to their resistance to most conventional antibiotics.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

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