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Antibacterial Activity of *Citrullus lanatus* Seed Extract against Clinical Isolates of *Klebsiella pneumoniae* and *Staphylococcus aureus*

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Abstract
As a result of increased emergence of bacterial resistance to the conventionally used antibiotics, it is necessary to search for alternatives from other sources like plant materials. This study was aimed at evaluating the in vitro antibacterial activity of Citrullus lanatus seed extract against isolates of Klebsiella pneumoniae from urine and Staphylococcus aureus from wound. The seeds were extracted using distilled water and methanol via cold maceration and then analysed for the presence of phytochemicals using standard methods. Tannins, steroids, cardiac glycosides and carbohydrates were present in both extracts. Only the aqueous extract contained alkaloids. The antibacterial activity of the two extracts was determined by agar well diffusion method. Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were determined using broth dilution method. The aqueous extract had better activity than the methanol extract, having inhibition zones of 20 mm and 23 mm at 200 mg/mL and, 10 mm and 11 mm at 25 mg/mL against Klebsiella pneumoniae isolates respectively, and mean zone of inhibition between 27.50 mm to 29.33 mm at 200 mg/mL and, 16.50 mm to 17.33 mm at 25 mg/mL against Staphylococcus aureus isolates with MIC and MBC values of 0.195 mg/mL and 0.39 mg/mL against Klebsiella pneumoniae and, mean MIC and MBC values ranging from 0.30 mg/mL to 0.39 mg/mL and 0.78 mg/mL to 2.73 mg/mL against Staphylococcus aureus isolates. The results obtained reveal the potential use of Citrullus lanatus seeds in the development of standard antibiotics.

Keywords: Antibacterial, *Citrullus lanatus* seeds, Extract, *Klebsiella pneumoniae*, *Staphylococcus aureus.*

INTRODUCTION
Natural products such as plants extract, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug discoveries because of the unmatched availability of chemical diversity, and more than 80% of the world's population relies on traditional medicine for their primary healthcare needs (Cosa *et al.,* 2006). Medicinal plants are abundant source of antimicrobial (bioactive) molecules. A wide range of medicinal plant extracts are used to treat several bacterial infections owing to their antimicrobial activity

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(Vaou *et al*., 2021). Some of these bioactive molecules are screened and traded in market as raw material for many herbal industries (Renisheya *et al*., 2011).

Phytochemicals are compound produced by plants in diverse array either as primary or secondary metabolites. Many of the secondary metabolites have antimicrobial activities against some pathogenic microorganisms that are implicated in infections (Ashraf *et al*., 2023). It is widely accepted that the pharmacological effect of plants lies in the bioactive compounds they contain (Volekobia *et al*., 2001). The *Citrullus lanatus* belongs to the kingdom Plantae, order Cucurbitales, family *Cucurbitaceae,* genus *Citrullus* and species *Citrullus lanatus* (Laghetti and Hammer, 2001). Characteristically, the *Citrullus lanatus* plant is a prostrate, or climbing annual plant having several herbaceous, rather firm and, stout stem measuring up to 3 m in length (Hlaing *et al*., 2020). The young parts are densely woolly with yellowish (or brownish) hair, while the older parts usually become hairless (Laghetti and Hammer, 2001). The leaves are herbaceous but rigid, becoming rough on both sides 60-200 mm long and 40-150 mm broad, ovate in outline, sometimes unlobed, but usually deeply 3-lobed with the segments again lobed or doubly lobed, the central lobe is usually the largest (Laghetti and Hammer, 2001).

Microbial infection is the most burdensome infectious disease in many countries, leading to about 14-17 million deaths annually (Yusuf *et al*., 2015). Pharmaceutical industries have produced a number of new antibiotics in the last three decades. However, resistance to these antibiotic drugs by microorganisms is still on the increase. The problem of microbial resistance is growing and the outlook for the use of antimicrobial agents in the future is still uncertain (Gislene, 2000). Hence the increase searches for new antimicrobial agents from alternative sources. Plant-based constituents may exhibit different modes of action against bacterial strains which range from interference with the phospholipoidal cell membranes, which has as a consequence of increasing the permeability profile and loss of cellular constituents, damage of the enzymes involved in the production of cellular energy and synthesis of structural components, and destruction or inactivation of genetic material (Kotzekidou *et al*., 2008).

Study by Tettey *et al.* (2021) was carried out on the peels, seeds, rind and pulp of *Citrullus lanatus* to investigate the antioxidant and antibacterial activity of the fruit on a range of bacterial isolates including; *Enterococcus faecalis* (ATCC 19433), *Salmonella typhii* (ATCC 19430), *Staphylococcus aureus* (NCIMB 6571), *Staphylococcus albus, Pseudomonas fluorescens, Escherichia coli* (ATCC 25922), *Bacillus subtilis* (NCTC 10073), *Klebsiella oxytoca* (ATCC 13182), *Streptococcus salivanus* (DSM 20617), *Micrococcus liteus, Listeria innocua, Shigella sonnei* (DSM 5570) and *Salmonella enterica* (ATCC 13076) all of which were susceptible to two or more extracts of the fruit's part.

In this study, the seeds extracts of *Citrullus lanatus* were investigated to determine the phytochemical constituents and the *in vitro* antibacterial activity against clinical isolates of *Klebsiella pneumoniae* and *Staphylococcus aureus* from urine and wound specimens respectively.

MATERIALS AND METHODS

Study Area

The study was carried out in Zaria. Zaria is ancient town in Kaduna State, located between latitudes 11°03′ - 11°10′N and longitude 7°30 – 7°42′ E, with a total land mass of 563 km^2 and an estimated population size of 408,198 (Muhammad *et al*., 2021; NPC, 2010). Clinical samples

were collected from Ahmadu Bello University Medical Centre, Hajiya Gambo Sawaba General Hospital Zaria, Jama'a Hospital Samaru and Zaria Clinic Tudun Wada.

Ethical Clearance

Ethical approval was obtained from the Ethical Committee of Kaduna State Ministry of Health and University Medical Centre, Ahmadu Bello University. Ethical clearance obtained from Kaduna State Ministry of Health covered ethical approval from Hajiya Gambo Sawaba General Hospital, Zaria Clinic and Jama'a Hospital respectively.

Sample Collection

Fifteen (15) milliliter mid-stream urine samples (21 from Jama'a hospital, 19 from Zaria Clinic, 25 from Ahmadu Bello University Medical Center and 19 from Hajiya Gambo Sawaba General Hospital) were collected in sterile, dry, wide-necked, leak-proof containers by the patients while wound swabs were collected aseptically from the patients using sterile swab sticks (98 from University Medical Center, 30 from Zaria Clinic, 18 from Jama'a Hospital and 20 from Hajiya Gambo Sawaba) with the assistance of experienced laboratory personnel (Cheesbrough, 2006). All samples were labeled appropriately and transported to the Department of Microbiology Laboratory, Ahmadu Bello University for processing.

Isolation of Bacteria

Urine samples were inoculated onto sterilized MacConkey agar plates and incubated for 24 hours at 37 °C. Suspected *K. pneumoniae* colonies appeared large, pink, mucoid, round and elevated, with smooth surface on MacConkey agar plate after incubation while wound swabs were inoculated onto sterilized mannitol salt agar plates and incubated for 24 hours at 37 °C. Suspected *S. aureus* colonies appeared golden yellow on mannitol salt agar plate after incubation. These isolates were then Gram stained and characterized using suitable biochemical tests (Cowan and Steel, 2003).

Processing of *Citrullus lanatus* Seeds

Citrullus lanatus (watermelon) fruits were authenticated (Voucher Number 2234) in the Herbarium section of the Department of Botany, Ahmad Bello University Zaria, Kaduna State, Nigeria, after purchase from Jaja Village Bassawa, Sabon-Gari Local Government Area of Kaduna State, Nigeria. The fruits were washed and then cut open to obtain the seeds. The seeds obtained were washed with running tap water and air-dried for two days followed by pulverization using a blender (Kenwood Limited, United Kingdom, and Model No.: FP690 Series). The coarse seed material was then weighed with a weighing balance and kept in air-tight container until extraction (Adunola *et al.,* 2015).

Cold Extraction by Maceration

The blended seed material was subjected to solvent extraction using methanol and distilled water. A total of 150 g each of the dried seed material was soaked in 1000 mLof methanol and distilled water in a conical flask with frequent agitation to ensure proper extraction. The batch for methanol was extracted for 48 hours and that of water for 24 hours respectively (Ohunakin and Bolane, 2017; Bandar *et al.,* 2013). The mixtures were filtered using muslin clothe to obtain the liquid part (filtrate) of the mixture after the extraction periods. All the filtrates were evaporated using water bath set at 40 °C. The residues that remained in the evaporating dishes after complete evaporation were collected, weighed and then stored in air-tight containers for further analysis (Varghese, 2013).

Phytochemical Screening of the Extracts

The extracts were screened for the presence of alkaloids, tannins, flavonoids, triterpenes, steroids, saponins, cardiac glycosides, reducing sugars and carbohydrates according to standard procedure (Evans, 2002; Sofowora, 1993) in the Department of Pharmacognosy, Faculty of Pharmaceutical Sciences Ahmadu Bello University Zaria, Nigeria.

Preparation of Test Concentrations of the Extracts and Standard Inocula

Fifty percent (50%) Dimethyl sulfoxide (DMSO) solution was prepared by mixing 50 mL of sterile distilled water with 50 mL of 100% DMSO solution. Two grams (2 g) of each of the extracts were placed in 3 mL of the 50% DMSO contained in sterile sample containers and allowed to stand overnight for proper dissolution of the extracts. These were then made up to 10 mL by adding 7 mL each of sterile distilled water to give a concentration of 200 mg/mL. Concentrations of 100, 50 and 25 mg/mL were prepared by serial double dilution using the stock solution (200 mg/mL). The inocula for susceptibility testing were prepared from broth that have been inoculated with the test bacteria and incubated for 24 hours at 37 °C. The turbidity of each of the bacterial suspensions was prepared to match 0.5 McFarland which is approximately 1.5×10^8 CFU/mL for each isolate.

***In-vitro* Antibacterial Activity of the Extracts against the Isolates**

Antibacterial activity of *Citrullus lanatus* seed extracts was carried out using the agar well diffusion method (Hassan *et al*., 2011). Mueller Hinton agar was prepared according to manufacturer's instructions and sterilized for 15 minutes at 121 °C. The solidified sterile media contained in petri dishes were seeded with 0.1 mL standard inocula of the test bacteria using sterile cotton swabs. Furthermore, a sterile cork-borer of diameter 6.0 mm was used to bore wells in each agar plate after which 0.5 mL of each extract was introduced into the different wells. The plates were then left for one hour at room temperature for proper diffusion of the extracts into the agar. The plates were then incubated at 37° C for 24 hours. Ciprofloxacin (5 µg) was used as a positive control for all the isolates. At the end of incubation period, diameters of inhibition zone were measured using transparent ruler (Hassan *et al*., 2011).

Minimum Inhibition Concentration of the Extracts against the Isolates

The extracts were further assayed for minimum inhibitory concentrations (MIC). The broth dilution method was employed using Mueller Hinton broth (Andrews, 2001). Two-fold serial dilutions of the least concentration that inhibited the growth of the test organisms from the susceptibility testing were made to obtain different concentrations. Two milliliter (2 ml) of the test concentrations of the individual extracts that inhibited the growth were added to 2 ml of Mueller Hinton broth in test tubes resulting in concentrations that was half the least concentration that inhibited the growth. The rest of the concentrations were obtained in the same manner. One loop full of the standardized inocula was inoculated into the mixtures above, followed by incubation for 24 hours at 37 °C. The MIC was determined as the lowest concentration of the extracts which inhibited visible growth of the organisms after incubation period. Negative controls were set up containing Mueller Hinton broth only and Mueller Hinton broth with extracts only while positive controls were set up containing Mueller Hinton broth and the test organism only (Andrews, 2001).

Minimum Bactericidal Concentration of the Extracts against the Isolates

The minimum bactericidal concentration (MBC) determination was done by sub-culturing samples from tubes of the MIC onto Mueller Hinton agar plates. The MBC was taken as the

lowest concentration of the extracts that did not allow any bacterial growth on the surface of Mueller Hinton agar plate after incubation for 24 hours at 37 °C (Abdullahi *et al.,* 2011).

RESULTS

Table 1 shows the cultural, microscopic and biochemical characteristics of *Klebsiella pneumoniae* isolated from urine samples. Only two of the samples were positive for *Klebsiella pneumonia*; one from Zaria Clinic and the other from Jama'a Hospital. All other samples were negative for *Klebsiella pneumoniae*. Table 2 shows the cultural, microscopic and biochemical characteristics of *Staphylococcus aureus* isolated from wound. Fourteen samples were positive for *Staphylococcus aureus*; Six from University Medical Center, three from Hajiya Gambo Sawaba General hospital, two from Jama'a Hospital and three from Zaria Clinic while the rest of the samples were negative for *Staphylococcus aureus*. Table 3 shows the phytochemical profile of *Citrullus lanatus* seed extracts. Alkaloid was only present in the aqueous extract. Tables 4 show the antibacterial activity of *Citrullus lanatus* seed aqueous extract against *Klebsiella pneumoniae* using ciprofloxacin as positive control. Table 5 shows the antibacterial activity of *Citrullus lanatus* seed methanol extract against *Klebsiella pneumoniae* using ciprofloxacin as positive control. The aqueous extract produced wider zone of inhibition against the tested bacteria than the methanol extract with 23 and 20 mm zones of inhibition at 200 mg/mL and 11 mm and 10 mm at 25 mg/mL with MIC and MBC values of 0.195 mg/mL and 0.390 mg/mL against the isolates respectively. On the other hand, methanol extract produced 15 and 11 mm zone of inhibition against one of the isolates (ZRC14) at 200 and 25 mg/mL respectively with MIC and MBC of 1.560 and 3.125 mg/mL. The other *Klebsiella pneumoniae* isolate (JMH18) was resistant to the methanol extract.

Table 6 shows the antibacterial activity of *Citrullus lanatus* seed aqueous extract against *Staphylococcus aureus* isolates with mean zones of inhibition ranging from 27.50 to 29.33 mm at 200 mg/mL and 16.50 to 17.33 mm at 25 mg/mL and, mean MIC and MBC ranging from 0.39 to 1.37 mg/mL and 0.78 to 2.73 mg/mL respectively. Table 7 shows antibacterial activity of *Citrullus lanatus* seed methanol extract against *Staphylococcus aureus* with mean zone of inhibition ranging from 13.00 to 22.50 mm at 200 mg/mL and 10.00 to 15.17 mm at 25 mg/mL and mean MIC and MBC ranging from 1.56 to 4.17mg/mL and 3.13 to 8.33 mg/mL respectively.

Table 1: Cultural, Microscopic and Biochemical Characteristics of the *Klebsiella pneumoniae* Isolates in urine

Isolate's Code	Growth on MAC	GRM	Biochemical Characteristics							Isolate's Identity
			M	C	I	MR	VP	TSI	AH	
ZRC14	Pink, Mucoid Colonies	G -ve, short, plump and straight rods	-	+	-	-	+	A/AG	+	*K. pneumoniae*
JMH18	Pink, Mucoid Colonies	G -ve, short, plump and straight rods	-	+	-	-	+	A/AG	+	*K. pneumoniae*

Key: ZRC; Zaria Clinic, **JMH**; Jama'a Hospital, **MAC;** McConkey Agar, **G -ve**; Gram Negative, **GRM**; Gram Reaction and Morphology, **M**; Motility, **C**; Citrate, **I**; Indole, **MR**; Methyl Red, **VP**; Voges-Proskauer, **TSI**; Triple Sugar Iron, **AH**; Aesculin Hydrolysis, **A/AG**; Acid/Acid plus Gas, all numbers indicates sample number from the respective hospitals.

Table 2: Cultural, Microscopic and Biochemical Characteristics of the *Staphylococcus aureus* Isolates in wound swab

Isolate's Code	Growth on MSA	GRM	Biochemical Characteristics					Sugar fermentation						Isolate's Identity
			Ct	Cg	Ds	MR	VP	Lac	Tre	Glu	Mal	Gal	Suc	
UMC5	Yellow colonies	G+ve, Spherical cells in Clustes	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
UMC17	Yellow colonies	G+ve, Spherical cells in Cluster	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
UMC23	Yellow colonies	G+ve, Spherical cells in Cluster	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
UMC35	Yellow colonies	G+ve, Spherical cells in Cluster	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
UMC41	Yellow colonies	G+ve, Spherical cells in Cluster	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
UMC74	Yellow colonies	G+ve, Spherical cells in Cluster	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
HGS10	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
HGS16	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
HGS19	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
ZRC5	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
ZRC19	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
ZRC25	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
JMH8	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*
JMH11	Yellow colonies	G+ve, Spherical cells in Clusters	+	+	+	+	+	+	+	+	+	+	+	*S. aureus*

Key: UMC; University Medical Centre, **HGS**; Hajiya Gambo Sawaba, **ZRC**; Zaria Clinic, **JMH**; Jama'a Hospital **MSA;** Mannitol Salt Agar, **GRM**; Gram Reaction and Morphology, **G+ve**; Gram Positive, **Ct**; Catalase, **Cg**; Coagulase, **Ds**; DNAse, **MR**; Methyl Red, **VP**; Voges-Proskauer, **Lac**; Lactose, **Tre**; Trehalose, **Glu**; Glucose, **Mal**; Maltose, **Gal**; Galactose, **Suc;** Sucrose, all numbers indicate sample number from the respective hospitals.

Table 3: Phytochemical Profile of *Citrullus lanatus* Seed Extract

Phytochemicals	ASE	MSE
Carbohydrates	+	+
Reducing Sugars	-	+
Cardiac Glycoside	+	+
Saponins	-	+
Steroids	+	+
Triterpenes	-	+
Flavonoids	-	+
Tannins	+	+
Alkaloids	+	-

Key: ASE; Aqueous Seed Extract, **MSE**; Methanol Seed Extract, **(+)**; Present, **(-)**; Absent.

Table 4: *In vitro* Antibacterial Activity of *Citrullus lanatus* seed Aqueous Extract against *Klebsiella pneumoniae*

Isolate's code	Concentration/Zone of Inhibition (mm)						
	200 mg/mL	100 mg/mL	50 mg/mL	25 mg/mL	Cip (5 µg)	MIC	MBC
ZRC14	23	19	14	11	28	0.195	0.390
JMH18	20	16	12	10	27	0.195	0.390

Key: ZRC; Zaria Clinic, **JMH**; Jama'a Hospital, **Cip;** Ciprofloxacin, **MIC;** Minimum Inhibitory Concentration, **MBC;** Minimum Bactericidal Concentration, all numbers indicates sample number from the respective hospitals.

Table 5: *In vitro* Antibacterial Activity of *Citrullus lanatus* seed Methanol Extract against *Klebsiella pneumoniae*

Isolate's code	Concentration/Zone of Inhibition (mm)						
	200 mg/mL	100 mg/mL	50 mg/mL	25 mg/mL	Cip (5µg)	MIC	MBC
ZRC14	15	13	12	11	28	1.560	3.125
JMH18	0	0	0	0	27	-	-

Key: ZRC; Zaria Clinic, **JMH**; Jama'a Hospital, **Cip;** Ciprofloxacin, **MIC;** Minimum Inhibitory Concentration, **MBC;** Minimum Bactericidal Concentration, **-;** Not Determined, all numbers indicates sample number from the respective hospitals.

Table 6: *In vitro* Antibacterial Activity of *Citrullus lanatus* seed Aqueous Extract against *Staphylococcus aureus*

Isolate's code	Concentration/ Mean Zone of Inhibition (mm)					Mean	
	200 mg/mL	100 mg/mL	50 mg/mL	25 mg/mL	Cip (5 µg)	MIC	MBC
UMC (n=6)	29.33	24.33	20.33	16.50	27.67	1.37	2.73
HGS (n=3)	31.33	27.00	22.00	17.00	26.67	0.39	0.78
ZRC (n=3)	29.67	25.33	21.33	17.33	29.00	1.30	2.60
JMH (n=2)	27.50	22.00	18.00	16.50	28.50	0.39	0.78

Key: UMC; University Medical Centre, **HGS;** Hajiya Gambo Sawaba, **ZRC**; Zaria Clinic, **JMH**; Jama'a Hospital, **Cip;** Ciprofloxacin, **MIC;** Minimum Inhibitory Concentration, **MBC;** Minimum Bactericidal Concentration.

Table 7: *In vitro* Antibacterial Activity of *Citrullus lanatus* seed Methanol Extract against *Staphylococcus aureus*

Isolate's code	Concentration/Mean Zone of Inhibition (mm)					Mean	
	200 mg/mL	100 mg/mL	50 mg/mL	25 mg/mL	Cip (5 µg)	MIC	MBC
UMC (n=6)	22.5	19.83	17.17	15.17	27.67	4.17	8.33
HGS (n=3)	25.00	21.67	18.67	14.67	26.67	1.56	3.13
ZRC (n=3)	16.67	14.00	12.33	10.00	29.00	1.56	3.13
JMH (n=2)	13.00	11.00	10.00	10.00	28.50	1.56	3.13

Key: UMC; University Medical Centre, **HGS;** Hajiya Gambo Sawaba, **ZRC**; Zaria Clinic, **JMH**; Jama'a Hospital, **Cip;** Ciprofloxacin, **MIC;** Minimum Inhibitory Concentration, **MBC;** Minimum Bactericidal Concentration.

DISCUSSION

The susceptibility of the bacterial isolates to the extracts could be attributed to the presence of the phytochemicals in the extracts (Nzogong *et al.,* 2018). For instance, saponins mode of action is believed to be alteration of membryonic properties which involves damaging of the cell membranes thereby causing leakage of cellular materials, ultimately leading to cell death (Mshvildadze *et al.,* 2000), and destabilization of the surface tension of the extracellular medium (Aliyu *et al.,* 2011). While that of flavonoids is suggested to be inhibition of peptidoglycan and ribosome synthesis, resulting in damage to the peptidoglycan layer and a cell devoid of ribosomes, inhibition of activity of certain extended beta-lactamases and alteration of outer membrane permeability (Eumkeb *et al.,* 2011). Tannins act by reacting with protein to form stable soluble compound thereby killing the bacteria by directly damaging the cell membrane (Sham *et al.,* 2010). The difference in response by the bacterial isolates to the extracts could be due to strain variability (Reynolds, 2017). The aqueous extract showed better activity with regards to zones of inhibition as compared to the methanol extract. This could be due to the fact that alkaloid was present only in the aqueous extract but absent in the methanol extract whose mode of action is believed to be interference of DNA synthesis through topoisomerase inhibition, since alkaloid is a compound known to be a DNA intercalator (Vinoth, 2013). The mechanism by which alkaloids act is also suggested to be as a result of cell lysis and morphological changes of *Staphylococcus aureus* (Sawer *et al.,* 2015). Both

extracts showed broad spectrum activity. However, *Staphylococcus aureus* was more susceptible to the extracts than *Klebsiella pneumoniae* which may be due to their differences in cell wall composition. Though, both bacterial cells are surrounded by peptidoglycan layer, that of the Gram-negative bacteria is surrounded by an additional outer membrane containing lipopolysaccharides which act as a barrier to many substances including antibacterial agents (Klancnik *et al.,* 2010; Silhavy *et al.,* 2010; Tortora *et al.,* 2010). The methanol extract had more phytochemicals than the corresponding aqueous extract. Although, other phytochemicals with known antibacterial activity were present in the methanol extract, it is likely that they produce better activity only in the presence of alkaloids because of the synergistic activity of phytochemicals.

CONCLUSION

Results obtained in this study have shown that *Citrullus lanatus* seed extract was effective in the control of infections caused by *Staphylococcus aureus* and *Klebsiella pneumoniae*. The results obtained in this study also revealed the potential use of *Citrullus lanatus* seeds in the development of standard therapeutic agents that could be used in the treatment of infections caused by these pathogens.

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