International Journal of Current Trends in Pharmaceutical Research
CODEN (USA): IJCTGM | ISSN: 2321-3760
Journal Home Page: www.pharmaresearchlibrary.com/ijctpr

RESEARCH ARTICLE

Effect of extraction solvents on the phytochemical constituents and antibacterial property of leaf extracts of *Momordica balsamina* Linn (Cucurbitaceae) found in North Central Nigeria

Jonathan. O. Kadiri*, Ignatius. S. Okafor and Ikoni. J. Ogaji

Department of Pharmaceutical Technology and Industrial Pharmacy, Faculty of Pharmaceutical Sciences, University of Jos, Jos, Nigeria

ABSTRACT

Momordica balsamina has been used traditionally in the management of microbial infections and chronic diseases. The purpose of this work was to evaluate the effect of extraction solvents on the phytochemical constituents and antibacterial activity of *M. balsamina* on some test organisms. The leaf of *M. balsamina* was sequentially extracted with hexane, dichloromethane, acetone, methanol and water with per cent yields of 0.34, 1.96, 1.2, 6.7 and 21 % respectively. Although phytochemical screening revealed that the plant contains alkaloids, flavonoids, saponins, tannins, steroids, carbohydrate and cardiac glycosides, only carbohydrates, steroids and cardiac glycosides were found in varying degrees in all the extracts. Alkaloids, tannins and flavonoids were present only in the aqueous and methanolic extracts. This variation in the phytochemical constituents of the extracts was attributed to the differential solubility of the phytochemical constituents in the solvents, and was responsible for the extent of antibacterial activity possessed by the extracts. The extracts were tested against strains of *Staph. aureus, B. subtilis, Strept. pneumonae, E. coli, S. typhi and P. aeruginosa* using the agar diffusion and streaking methods. The results showed that the methanolic extract exhibited MIC and MBC of 31.25 mg for all the test organisms, except *E. coli* and *S. typhi*. The MIC of the water extract was 31.25 mg against *Staph. aureus* and *P. aeruginosa*; and 62.5 mg against *B. subtilis* and *Strept. pneumonae*; whilethe MBC was 62.5 mg against the test organisms, except *E. coli* and *S. typhi. E. coli* was the most sensitive organism with MIC of 15.625 mg for extracts of both solvents. On the other hand, *S. typhi* exhibited the least sensitivity for the two solvents, with MIC of 62.5 and 125 mg for the methanolic and water extracts respectively. Both aqueous and methanolic extracts of the leaves of *Momordica balsamina* demonstrated antibacterial activity, while those obtained with hexane, dichloromethane or acetone did not demonstrate any appreciable antibacterial activity against the test organisms.

Keywords: *Momordica balsamina*, Extraction Solvents, Microorganisms, Antibacterial

ARTICLE INFO
Corresponding Author
Jonathan. O. Kadiri
Department of Pharmaceutical Technology
and Industrial Pharmacy,
University of Jos, Jos, Nigeria
MS-ID: IJCTPR4144

JOURNAL QR-CODE

Article History: Received 25 Oct 2019, **Accepted** 27 Dec 2019, **Available Online**15 Jan 2020

Citation: *Jonathan. O. Kadiri*, *et al.* Effect of extraction solvents on the phytochemical constituents and antibacterial property of leaf extracts of *Momordica balsamina* Linn (Cucurbitaceae) found in North Central Nigeria. *Int. J. Curnt. Tren. Pharm, Res.*, 2020, 8(1): 12-18.

C O N T E N T S

1. Introduction 13
2. Materials and Methods. 13
3. Results and discussion 14
4. Conclusion. 17
5. Acknowledgement 18
6. References. 18

1. Introduction

In most cultures from ancient times to the present day, plants are used as a source of medicines by man to control diseases in humans and animals. Plants are the basis of medicinal systems that have been in existence for thousands of years and they have continued to provide humanity with new remedies (Gurib-Fakim, 2006)such as anti-bacterial (Kouser and Qureshi ,2013); anti-fungal (Mishra *et al*, 2010; Webster *et al.*, 2008); worm expellant (Naven*et al.*, 2013) and in altering and correcting the body functions (Kumar *et al*., 2013).Medicinal plants are abundant in tropical rainforest zones, and Nigeria is one country that is abundantly blessed with them (Sofowora, 2012). These medicinal plants contain bioactive compounds such as alkaloids, phenols, tannins, steroids, glycosides, resins, volatile oil, and fixed oil. These constituents are normally extracted using various extraction solvents of different polarity index such as hexane, dichloromethane, methanol and water having polarity index of 0.1, 3.1, 5.1 and 10.2 respectively using various extraction methods such as maceration and soxhlex extractions (Gupta et al, 2012).In extraction, the principle of 'like dissolves like' is normally employed. For instance, hexane extracts waxes and fats; dichloromethane extracts alkaloids, terpenoids and aglycones; methanol extracts medium polar constituents such asflavones, phenones and polyphenols; and water extracts polar constituents such as, amino acids, saponins, lectins and polypeptides (Gupta et al, 2012).

Bacteria are microorganisms that are distributed widely in nature in large numbers. Most bacteria serve as useful scavengers in the breakdown of organic matter but some invade tissues and produce disease in higher animals and plants and can cause the death of the host (Carter, 2005). Antibiotic is a substance produced by an organism or a similar substance produced by other means that is antagonistic to the growth or life of other microorganisms and is used to treat diseases in man, animals or plants (Carter, 2005). They can retard or stop the growth of other bacteria by inhibiting cell wall synthesis (e.g. penicillins and vancomycin); by altering cell membrane structure (e.g. polymixin), by interfering with DNA replication (e.g. quinolones) and RNA synthesis (e.g. rifampicin); by interfering with protein synthesis (e.g. erythromycin and gentamycin); by interfering with the metabolites (e.g. sulphonamides) (Prescott, Harley and Klein, 2005).

Some researchers have made various attempts to formulate extracts into various dosage forms. For example, *Cymbopogoncitratus* oil has been formulated into ointment as antimicrobial and mosquito repellant (Majumder & Majumder (2013); Oyedele, Gbolade, Sosan, Adewoyin, Soyelu & Orafidiya, 2002). Also, Chhetri et al. (2010) with a suitable ointment base, formulated a polyherbal ointment comprising *Azadiractaindica¸ Elsholtziafructicosa*, *Eucalyptus globulus*, *Ocimum santrum*and *Rhododendron setosum* against *Staphylococcus aureus, Escherichia coli* and *Klebsiella*species. In the same vein, Herbal extracts of *Prosopis Africana* and *Anogeissusleiocarpus* had been formulated into tablet for the treatment of asthma using suitable tablet excipients such as maize starch and lactose (Emeje et al, 2011).There is the need to seek for alternative antibiotics that are not easily prone to bacterial resistance from medicinal plants. More than before, interest in herbal drugs has increased in order to find solution to the menace of bacterial resistance. The leaves and fruit extracts of *Momordica balsamina* were reported to possess antiplasmodial activity and is being used against malaria in African traditional medicine. The extracts from various parts of this plant have been reported to possess shigellocidal, anti-diarrhoeal, antiseptic, antibacterial, antiviral, anti-inflammatory, hypoglycemic and antimicrobial properties (Akinyemi*et al*., 2005; Hassan and Umar, 2006; Jigam*et al*., 2004). The aim of this study is to evaluate the effect of extraction solvents on the antibacterial property of *Momordica balsamina* leaf.

2. Materials and methods

Materials: *Momordica balsamina fresh* leaves were collected from Jos North Area of Plateau State, Nigeria in October 2014. They were identified, authenticated and deposited with voucher number 288;amoxicillin powder was donated by Tinna Pharmaceutical Industry, Jos Nigeria; penicillin skin ointment was purchased from Medlane Pharmacy, Apata Street Jos, Nigeria. Other materials used in the work were of analytical grade.

Preparation and extraction of *Momordica balsamina* leaves: The leaves were air-dried and powdered in our laboratory. A 300 g quantity was sequentially extracted by maceration for 7 days in glass containers with closures using 500 ml hexane, dichloromethane, acetone, methanol and distilled water in order of increasing polarity index. The extracts were filtered using Whatman No. 1 filter paper. Evaporation of solvent from the extract was carried out at 40^{o}C using rotary evaporator (Model RE 100, England).

Phytochemical Screening:

The phytochemical screenings were carried out using the techniques adapted from Gul, Jan, Faridullah, Sherani&Jahan (2017) and Sofowora (2012).

Alkaloidal screening: To a 0.2 g sample of the methanolic extract contained in a test tube was added 5 ml of 2N

hydrochloric acid. The mixture was heatedon a boiling water bath for about 5 min. It was cooled, filtered and the filtrate divided into two equal portions. One portion was treated with few drops of Mayer's reagent, and the other with equal amounts of Dragendorff's. Turbidity of the resulting precipitate in both reagents indicated the presence of alkaloids.

***Tannin screening*:** A 0.2 g sample of each extract was mixed with10 ml of distilled water and heated on a boiling water bath for about 5 min. The mixture was filtered and 5 % (w/v) solution of ferric chloride was added to the filtrate. The formation of dark green solution was an indication of the presence of tannins.

***Saponin screening*:** A 0.2 g sample of each extract was shaken in a test tube with 5 ml of distilled water and heated on a water bath to boil for about 5 min. Formation of strong and stable foam (1.7 cm height) was an indication of the presence of saponins.

***Terpenoid screening*:** A 0.2 g sample of each extract was separately mixed with 2 ml of chloroform ($CHCl_3$). Then 3 ml of concentrated sulphuric acid was added carefully to form a layer. The formation of reddish-brown coloration at interface indicated the presence of terpenes.

***Steroid screening (Salkowski test)*:** A 0.2 g sample of the extract was treated with 2 ml of chloroform. Then 2 ml of concentrated sulphuric acid was added, shaken and allowed to stand. Red coloration in the chloroform layer and greenish yellow in the acid layer showed the presence of sterols.

***Flavonoid screening*:**From each crude extract, 0.2 g was dissolved in 5 ml of 0.1M sodium hydroxide (NaOH). Then 5 ml of 1M hydrochloric acid (HCl) was added. A yellow solution that turns colourless showed the presence of flavonoids.

***Anthraquinone screening*:** A 0.5 g sample of the extracts was boiled with 10% of hydrochloric acid for few minutes in a water bath and filtered. The filtrate was allowed to cool and equal volume of chloroform ($CHCl_3$)added. Few drops of 10% ammonia solution was added to the mixture and heated to boiling. The formation of rose-pink colour showed the presence of anthraquinones.

***Glycoside screening*:** A 0.2 g sample of each extract was hydrolysed in 10 ml of 1% HCl solution and neutralized with an equal volume of 10% of NaOH solution. A few drops of Fehling's solutions A and B were added. The formation of red precipitate indicated the presence of glycosides.

Evaluation of antibacterial activity of the extracts

Qualitative antibacterial assay:

The agar well diffusion method was used to test the effect of the extracts on *E. coli, S.aureus, B. subtilis, S. typhi. S.pneumonae and P. aeruginosa.* The bacterial strains testedwere inoculated into nutrient broth and incubated at 37 °C for 24 h. They were centrifuged and the supernatant discarded, and the bacterial sediment brought to 0.5 McFarland Standard. A 200 µl of the bacterial suspension was micro pipetted into the Universal Bottles containing the sterile nutrient agar which was about to set. This was mixed and poured into sterile Petri-dishes. A flame-sterilized cork borer (5 mm diameter) was used to make wells in the agar after setting. A 100 µl of each extract sample was introduced into the wells with a micropipette. The Petri-dishes were allowed to set before incubation at 37°C for 24 h (Model E115, Harrow Scientific Ltd, England). The inhibition zone diameters (mm) were measured. Amoxicillin and dimethyl sulphoxide (DMSO) were respectively used as positive and negative controls. The experiments were replicated. Concentrations of the aqueous and methanolic extracts up to 500 mg/ml were similarly investigated.

Quantitative antibacterial assay:

The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of the plant extracts with reasonable activity against the test organisms were carried out according to the method described by Andrews (2001). The MIC was determined by streaking the test organisms on agar. The extracts were diluted with double strength agar about to set to obtain concentrations of 250, 125, 62.5, 31.25, 15.625, 7.8 and 3.9 mg/ml. Standard suspensions of known concentrations of the test organisms were streaked on the set mixture of plant extract and agar using sterile loop and incubated at 37 °C between 24 - 48 h. The lowest concentration that exhibited no visible growth after 48 h was regarded as the final MIC. The concentration of the extracts that produced no visible growth within 48 h were streaked on freshly prepared nutrient agar plates and incubated at 37 °C for 24 - 48 h. The lowest concentration that yielded no single bacterial colony was taken as the MBC.

3. Results and Discussion

Extract yields and characteristics:

Table 1shows the solvents used in the sequential extraction of *Momordica balsamina* leaf in order of their polarity index, the per cent yield and extract characteristics. Hexane gave a yield of 0.34 % and the extract is oily in appearance. Dichloromethane gave a yield of 1.96 % and the extract is sticky. Acetone had a yield of 1.2 % and the extract is sticky. The methanolic extract gave a yield of 6.7 % and the extract is gummy. The water extract gave a yield of 21 % and is hygroscopic. It can be seen that the yield increased in order of increasing polarity index of the solvents, except dichloromethane and acetone.

Phytochemical Constituents of *Momordica balsamina* extracts:

Table 2 shows the phytochemical constituents of the extracts. Alkaloids, tannins and flavonoids were found in the aqueous and methanolic extracts, but these were absent in the acetone, dichloromethane and hexane extracts. Carbohydrates, steroids and cardiac glycosides were also found in varying degrees in all the extracts. This variation was due to the differential solubility of the plant constituents in the solvents and was responsible for the extent of antibacterial activity possessed by the extracts. No trace of anthraquinones was detected in the extracts. Karumi*et a*l (2006) reported the presence of alkaloids, saponins, tannins and reducing compounds in *Momordica balsamina* leaf, indicating that the constituents of this plant may be the same in terms of the phytochemicals irrespective of the geographical source.

The hexane extract possessed the highest concentrations of steroids. Taleb-Contini*et al*. (2003) reported that steroids possessed activity against Gram- positive *S. aureus* and *S. mutans*. It may be inferred that the activities of the dichloromethane and acetone extracts against the test organisms is due to the steroids and other phytochemicals present. In the same vein, acetone and dichloromethane extracts possessed more of the cardiac glycosides than any of the extracts, while water extract had the highest concentration of saponins.The plant *Momordica balsamina* may have an ionotropic effect on the heart. This effect may not be pronounced in the aqueous extract because it appeared in trace quantity. They possess more activity against Gram-positive bacteria, such as *S. aureus* and *B. subtilis*, than the Gram-negative microorganisms, such as *E.coli* and fungi (Avato*et al*., 2006; Soetan*et a*l., 2006).

The plant *Momordica balsamina* possesses alkaloids, tannins, flavonoids and saponins which in no doubt have contributed to the antibacterial property of this plant. The higher inhibition zone diameter exhibited by the methanolic and aqueous extracts in the qualitative test shows that they contained more of these phytochemicals than the other extracts evident by the phytochemical screening result (Table 2).

Flavonoids are polyphenols distributed widely among various plants. They contain more than one benzene ring in their structure and are used as antioxidants or free radical scavengers (Enwa*et al*., 2014). The presence of flavonoids in this plant extract suggests its potential usefulness as antiviral, antibacterial and antifungal because flavonoids have been known to have antioxidants or free radical scavengers properties (Cushine and Lamb, 2005;Enwa*et al*., 2014). Flavonoids form part of these bioactive compounds and serve as plant defence mechanism against pathogenic microorganisms. Flavonoids have also been found to inhibit alpha glucosidase enzyme in the gastrointestinal tract there by slowing down the digestion of polysaccharides into monosaccharides. Tannins have been reported to be bacteristatic against some microorganisms.

Some flavonoids have been shown to exhibit inhibitory effects against alpha-glucosidase enzymes (Proença*et al*., 2017).This directly reduces the influx of glucose into the circulation bringing blood glucose under control. The use of *M. balsamina* in traditional medicine for the treatment of diabetes might be as a result of this type of flavonoids. Plant phenolics are aromatic benzene ring compounds with one or more hydroxyl groups which are produced by plants majorly for protection against stress (Bhatta, Sood & Citovsky, 2010).methanol is one of the solvents used in the extraction of low molecular polyphenols(Dai and Mumper, 2010) while aqueous acetone is very good in the extraction of high molecular polyphenolsPhenolic compounds obtained in this study suggest the potential of this plant as anti-oxidants and anti-inflammatory agent because phenolic compounds work as antioxidant and anti-inflammatory agents by interfering with inflammatory pathways causing the reduction in the feeling of pains in arthritis and osteoarthritis (Yousef*et al,* 2015). This justifies the local use of the plant as anti-oxidants and anti-inflammatory agent. Plant phenolics include phenolics acids, flavonoids, tannins and the less common stilbenes and lignans (Dai and Mumper, 2010).

The largest group of plant secondary metabolites is the alkaloids which comprise nitrogen bases synthesized from amino acids with various radicals containing one or more of the hydrogen atom from the peptide ring. They act in plant defence against pathogenic organisms. They have been used widely as pharmaceuticals, narcotics, stimulants and poisons (Enwa*et al*., 2014).Because of the forms in which alkaloids exist in plants such as free, organic and inorganic salts alkaloids, their extraction involves using polar and medium polar solvents such as water, methanol and chloroform (Yubin et al., 2014) .Alkaloids in the indolizidine, isoquinoline, quinolone, agelasine and polyamine classes are proven antibacterials. The mechanisms of action of these alkaloids as antibacterial include inhibition of nucleic acid synthesis, perturbing of Z-ring and inhibition of cell division (Cushnie*et al*., 2014).

Table 3 shows the inhibition zone diameter of the extracts against the test organisms at concentration of 125 mg/ml. The average inhibition zone diameter (IZD) of all the tested organisms for each extract was highest for the methanolic extract (18±0.84 mm) followed by water extract (14.83 ± 2.14 mm) and dichloromethane extract (13.83±1.29 mm). The least was acetone (12.75±2.34 mm). The most sensitive microorganism to the extracts was *E. coli* (16.00±1.68 mm) followed by *P. aeruginosa* (15.75±1.32 mm). *S. typhi*, *S. pneumonae, B. subtilis and S. aureus* had IZD of 15.13 ± 3.64, 15.13 ± 2.59, 13.75 ± 4.93 and 13.38 ± 2.75 mm respectively for the extracts. The qualitative antimicrobial test result (Table 3) reveals that all the extracts showed antibacterial activity. The methanolic extract had the highest activity against all the test organisms with the average inhibition zone diameter of 18 ± 0.84 mm followed by the water extract (IZDe, 14.83 ± 2.14 mm). Dichloromethane and acetone extracts had 13.83 ± 1.29 and 12.75 ± 2.34 mm respectively. Amongst the test organisms, *E.coli* was the most sensitive with average IZD_O of 16.00 ± 1.68 mm, followed by *P. aeruginosa* (15.75 ± 1.32 mm). These results support the work of Jigam et al. (2004) and Otimenyin et al. (2008) who reported that *Staph. aureus*, *S. typhi*, *P. aeruginosa*, *E.coli*, *P. mirabilis*, *K. pneumoniae* and *B. subtilis*were sensitive *to M. balsamina*methanolic extract. This work also established that the plant has activity against *Strept. pneumoniae* and that *E.coli* was the most sensitive amongst the test organisms.Tables 4and 5 show the minimum inhibitory concentrations (MICs) of the aqueous and methanolic extracts respectively against the organisms tested. The MIC of 15.625 mg/ml of the aqueous extract for *E.coli* was the least. The MIC of the extract for *P. aeruginosa* and *S. aureus* (31.25 mg/ml) is similar. The MIC of the aqueous extract (62.5 mg/ml) for *B. subtilis* and *S. pneumoniae* are also similar, while that for *S. typhi* was the highest (125 mg/ml). Consequently, *E.coli* was the most sensitive organism, while *S. typhi* was the least sensitive to

the aqueous extract. In the case of the methanolic extract, *E. coli* with MIC of 15.625 mg/ml was also the most sensitive, followed by *S. aureus, B. subtilis, S. pneumonae and P. aeruginosa*, with no growth even at concentrations of 31.25 mg/ml of the extract. *S. typhi* was the least sensitive, with MIC of 62.5 mg/ml. Tables 6 and 7 show the minimum bactericidal concentrations (MBCs) of the aqueous and methanolic extracts against the organisms tested. E. coli (15.625 mg/ml) was most sensitive to the aqueous extract. This was followed by *S. aureus, B. subtilis, S. pneumonae and P. aeruginosa* with no growth at 62.50 mg/ml of the extract. *S. typhi* was the least sensitive (125 mg/ml) to the aqueous extract. The minimum bactericidal concentration (MBC) of the methanolic extract against the test organisms showed that *E. coli* was the most sensitive (15.625 mg/ml) followed by *S. aureus, B. subtilis, S. pneumonae and P. aeruginosa* with no growth at 31.25 mg/ml of the extract. *S. typhi* was the least sensitive (125 mg/ml). The qualitative and quantitative test results revealed that the methanolic extract possessed lower MIC and MBC than the water extract. This extract demonstrated inhibition against *S. typhi* at 62.25 mg/ml while the corresponding concentration for the water extract was 125 mg/ml. The methanolic extract demonstrated inhibition against 83.3% of the test organisms at 31.625 mg/ml while that of the aqueous extract was 50 %. The work revealed that the methanolic extract had little solubility in water. Traditionally, the water extract has been used for the treatment of bacterial infections including typhoid fever. The MIC and MBC results of the water extract justify the use of the plant traditionally in the management of bacterial infections.

Table 1: Effect of Extraction Solvent on the Yield and Texture of Crude Extracts of *Momordica balsamina*

S/No	Extract	Yield(%)	Characteristic
1	Hexane	0.34	oily
2	Dichloromethane	1.96	Sticky
3	Acetone	1.2	Sticky
4	Methanol	6. 7	Gummy
5	Water	21	Dry hygroscopic lumps

Table 2: Phytochemical Composition of the Plant Extracts Using Different Solvents

Constituent	Water	Methanol	Acetone	Dichloromethane	Hexane
Alkaloids	++	+	-	-	-
Tannins	++	+	-	-	-
Flavonoids	++	++	-	-	-
Saponins	+++	-	-	-	-
Carbohydrate	++	++	++	+	++
Steroids	+	++	++	++	+++
Antraquinones	-	-	-	-	-
Cardiac glycolsides	+	++	+++	+++	++

Present or trace (+), moderately present (++), highly present (+++), Not present (-)

Table 3: Effect of Extractive Solvent on the Zone of Inhibition of Extracts of *Momordica balsamina* leaf at Concentration of 125 mg/ml on Test organisms

	Inhibition zone diameter (mm)						
Dcm (125 mg/ml)	Acetone	Methanol	Water	DMSO	Average IZDo (10mg/ml)	Amoxycillin	Microorganism
S. aureus	11.5	11	17	14	0	13.38±2.75	24
B. subtilis	15	10.5	18	11.5	0	13.75±4.93	20
S. pneumonae	13.5	14	19	14	0	15.13±2.59	27
E. coli	15	15	18.5	15.5	0	16.00±1.68	29.5
S. typhi	14	10.5	18.5	17.5	0	15.13±3.64	27
P. aeruginosa	14	15.5	17	16.5	0	15.75±1.32	27.5
Average IZDe	13.8 ±1.29	12.75±2.3	18 ± 0.8	14.83 ± 2.1	0	-	25.83 ± 3.4

IZDe = extract inhibition zone average; IZDo – microorganism inhibition zone average; Dcm = dichloromethane; DMSO = dimethyl sulphoxide; n = 2

Table 4: Minimum Inhibitory Concentration of Water Extract against the Test Organisms

Microorganism	Water extracts concentration (mg/ ml)						
	250	125	62.5	31.25	15.625	7.8	3.9
S. aureus	-	-	-	-	+	+	+
B. subtilis	-	-	-	+	+	+	+
S. pneumonae	-	-	-	+	+	+	+
E. coli	-	-	-	-	-	+	+
S. typhi	-	-	+	+	+	+	+
P. aeruginosa	-	-	-	-	+	+	+

(+) = growth; (-) = no growth

Table 5: Minimum Inhibitory Concentration of Methanolic Extract against the Test Organisms

Test microorganism	Methanolic extracts concentration (mg/ ml)						
	250	125	62.5	31.25	15.625	7.8	3.9
S.aureus	-	-	-	-	+	+	+
B. subtilis	-	-	-	-	+	+	+
S. pneumonae	-	-	-	-	+	+	+
E. coli	-	-	-	-	-	+	+
S. typhi	-	-	-	+	+	+	+
P. aeruginosa	-	-	-	-	+	+	+

(+) = growth; (-) = no growth

Table 6: Minimum Bactericidal Concentration of Water Extract against the Test Organisms

Test microorganism	Water extracts concentration (mg/ ml)						
	250	125	2.50	31.25	15.625	7.80	3.90
S.aureus	-	-	-	+	+	NT	NT
B. subtilis	-	-	-	+	+	NT	NT
S. pneumonia	-	-	-	+	+	NT	NT
E. coli	-	-	-	-	-	NT	NT
S. typhi	-	-	+	+	+	NT	NT
P. aeruginosa	-	-	-	+	+	NT	NT

NT = Not tested; (+) = growth; (-) = no growth

Table 7: Minimum Bactericidal Concentration of Methanolic Extract against the Test Organisms

Test microorganism	Methanolic extracts concentration (mg/ ml)						
	250	125	62.5	31.25	15.625	7.8	3.9
S. aureus	-	-	-	-	+	NT	NT
B. subtilis	-	-	-	-	+	NT	NT
S. pneumonia	-	-	-	-	+	NT	NT
E. coli	-	-	-	-	-	NT	NT
S. typhi	-	-	+	+	+	NT	NT
P. aeruginosa	-	-	-	-	+	NT	NT

4. Conclusion

The phytochemical screening revealed that the solvents extracted the phytochemical constituents of the leaf of this plant according to their individual polarity index which had direct bearing on their antimicrobial activities. Although all the extracts demonstrated antibacterial properties, the methanolic and aqueous extracts exhibited more activity against the test organisms than the other extracts. Therefore the phytochemical constituents responsible for antibacterial activity in *Momordica balsamina* leaf may be extracted with methanol or water. These extracts may be used in the formulation of dosage forms for external or oral use.

5. Acknowledgement

I would like to acknowledge the contributions of members of staff of Department of Pharmaceutical Microbiology and Biotechnology and the Department of Pharmacognosy and Traditional Medicine, Faculty of Pharmaceutical Sciences, University of Jos for their immense assistance during the research work.

6. References

[1] KOAkinyemi, UE Mendie, S T Smith, AO Oyelolu, and AO Coker (2005). Screening of some medicinal plants for anti-salmonella activity, J. Herb. Pharmacother, 5 (1), 45-60

[2] A Bhattacharya, P Sood, & V Citovsky (2010). The role of plant phenolics in defence and communication during agrobacterium and rhizobium infection. Mol. pl. path., 11 (5), 705 – 719.

[3] JS Carter, (2000). Suspensions In: Dispensing for Pharmaceutical students. 12th edition, New Delhi, India. CBS Publishers & Distributors, pp 100-119.

[4] JS Carter (2000). Powder flow and compaction In: Tutorial Pharmacy. 12th edition, New Delhi, India. CBS Publishers & Distributors, pp 211 - 231.

[5] J Dai, RJ Mumper (2010). Plant Phenolics: Extraction, analysis and their antioxidant and anticancer properties, Molecules, 15 (10), 7313 – 52.

[6] A Falodun (2010). Herbal medicine in Africa-distribution, standardization and prospects. Res. J. Phytochem., 4,154-161.

[7] A Gurib-Fakim (2006). Medicinal plants: traditions of yesterday and drugs of tomorrow. Mol. Aspects Med., 27 (1), 1-93.

[8] LG Hassan, KJ Umar (2006) Nutritional value of balsam apple leaves. Pak. J. Nutr.,5, 522–529.

[9] AA Jigam, HO Akanya, DJ Adeyemi (2004). Antimicrobial and antiplasmodial effects of Momordica balsamina. Nigeria J. Nat. Prod. Med., 8, 11–12.

[10] R Kouser, RQureshi (2013).Antimicrobial activity of Fagoniaindica from Thai desert, Punjab, Pakistan.Int. J. Phytomed., 5 (1), 113 – 118.

[11] A Kumar, M Asthana, P Roy, S Amdekar, V Singh (2013). : Phytochemistry and pharmacology of Pyrostegiavenusta: a plant of Family Bignoniaceae. Int. J. Phytomed., 5 (3), 257 – 261.

[12] MK Mishra, P Tiwari, DK Dash, RS Jodon, G Ghosh, BB Barik (2010). Antifungal Activity of Leptadenia reticulate Wight and Arn. Aerial parts. Int. J. Phytomed., 2(2). 172- 176.

[13] OS Otimenyin, MO Uguru, EB Akanbi (2008). Anti-diarrhea effect of aqueous extract of Momordica balsamina and Stachytarphetaindica in rats.J. Nat. Prod., 1, 36 – 45.

[14] LM Prescott, JP Harley, DA Klein (2005). Antimicrobial Chemotherapy In: Microbiology. 6thedition.McGrawHill.pp 779 – 798.

[15] T Selvamohan, V Ramadas, SSS Kishore (2012). Antimicrobial activity of selected medicinal plants against some selected human pathogenic bacteria. Adv. Appl. Sci.Res, 3 (5), 3374 – 3381.

[16] J Yubin, Y Miao,W Bing, Z Yao (2014). The extraction, separation and purification of alkaloids in the natural medicine, J. Chem. Pharm. Res., 6(1), 338 – 345.