ORIGINAL PAPER

Nig. J. Pharm. Res. 2019, 15 (1) pp 9-18
ISSN 0189-8434, e-ISSN 2635-3555 **Available online at http://www.nigjpharmres.com**

Antimicrobial Activity and Stability of *Andrographis paniculata* cream containing Shea Butter

O. A. ADELEYE [A-F], C. O. BABALOLA [C-F], M. N. FEMI-OYEWO [A-F], G. Y. BALOGUN [A-D]

Department of Pharmaceutics and Pharmaceutical Technology,
Olabisi Onabanjo University, Ago Iwoye, Ogun State, Nigeria.

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article.

Abstract

Background: Creams are semi-solid topical products which are intended to be applied to the skin or mucous membrane. Herbal medicated creams are used for various therapeutic purposes. The antimicrobial properties of *Andrographis paniculata* leaves have been studied by various researchers.

Objectives: The objective of this study is to formulate and evaluate the effect of shea butter (unrefined and refined) on the antimicrobial activity of *Andrographis paniculata* cream and also to investigate the physical stability of the cream under different storage temperature.

Methods: Different cream formulations containing 5, 10 and 20% *Andrographis paniculata* extract and shea butter were produced, physical properties of the cream were evaluated and susceptibility of the cream to *Staphylococcus aureus*, *Pseudomonas aureginosa*, *Escherichia coli*, *Aspergillus niger and Candida albicans* was determined from zones of inhibition produced on an agar plate. Physical stability was done by subjecting the creams to different storage temperatures.

Results: All the cream formulations were homogenous in appearance, soft, smooth, non-greasy and were oil-in-water type emulsion. Viscosity of the creams increased with incorporation of shea butter. The incorporation of shea butter in formulations containing aqueous or methanolic extracts enhanced the antimicrobial activity of the formulations. There was no significant difference between the antimicrobial activities of both extract against all the test organism except for *Aspergillus niger* in which methanolic extract showed a higher activity which was significantly different ($p<0.05$). The physical stability of the cream formulations was maintained within 30 days, no changes in colour, texture, and homogeneity.

Conclusion: Inclusion of shea butter synergized the antimicrobial activity of *Andrographis paniculata* cream.

Key words: Cream, shea butter, A*ndrographis paniculata*, aqueous extract, methanolic extract.

INTRODUCTION

Topical semi-solid dosage forms are usually available in the form of ointments, pastes, gels or creams. They may contain one or more active ingredients uniformly dispersed or dissolved in a base or they may not contain any active ingredient (Allen *et al.*, 2010).

Creams are homogeneous, semi-solid topical products intended to be applied to the skin or mucous membrane. Medicated creams are products with active component(s) and used for therapeutic purposes such as inflammation, infections etc. Non-medicated creams do not contain active ingredients and used mainly as cosmetics and in some skin conditions as moisturizer, emollient etc. They are semi-solid emulsions of either oil-in-water or water-in-oil type which are susceptible to breakage, shrinking, crystal growth and contamination if not properly stored.

Shea butter is extracted from shea nuts obtained from the shea tree *Vitellaria paradoxa*, family Sapotaceae. The nuts are small, hard, brown in colour and bean-shaped. Unrefined shea butter is the raw form which

involves just boiling and filtering to remove impurities while refined shea butter is bleached usually by treatment with bleaching agents like hexane. Shea butter is used as skin moisturizer, hair conditioner and for skin healing. It is used medicinally to treat skin inflammation, irritation, rashes in children, dermatitis and rheumatism (Hong *et al*., 1996). It is also used in cooking food, making candles, soaps and coating of wood products (Maranz *et al.,* 2004). Shea butter plant has been reported as a potent antimicrobial plant against bacterial and fungi infections (Ajijolakewu and Awarun, 2015).

Andrographis paniculata (*A. paniculata*) belongs to the family, Acanthaceae. The plant is an erect annual herb that is extremely bitter in taste in all parts of the plant, hence its common name, "king of Bitters". In India, it is called *Maha-tita.* It is widely distributed in tropical Asian region. It is cultivated in some countries because of its medicinal value (Ameh *et al.,* 2010). All parts of the herb have been widely used in Chinese and Ayurvedic medicine (Sheeja *et al., 2006*). It has been used traditionally for the treatment of inflammation, fevers, infectious diseases, cancer etc. (Balu and Alagesaboopathi, 1993; Jarukamjorn *et al.*, 2010).

The antimicrobial properties of the crude extract of *Andrographis paniculata* leaves have been studied by various researchers and found to be highly effective (Geetha *et al.,* 2017; Polash *et al.,* 2017). However, little attempt has been made to formulate *A. paniculata* extract into a herbal medicated cream.

The aim of this study was to formulate *A. paniculata* cream and evaluate the effect of unrefined and refined shea butter on the antimicrobial activity of *A. paniculata* cream and comparing the antimicrobial activity of methanolic extract of *A. paniculata* leaves with aqueous extract. Physical stability of the the formulations under different storage time and temperature was also investigated.

Figure 1: *Andrographis paniculata*

METHODOLOGY

Materials

Mueller Hinton and Sabouraud dextrose agar were purchased from Himedia Laboratories Pvt. India, Gentamycin cream (0.35%) and Ketoconazole cream (2.0%) were purchased from Drugfield Pharmaceutical Ltd, Nigeria.

Test organisms

The bacterial and fungi species used in this study are *Staphylococcus aureus, Pseudomonas aureginosa, Escherichia coli, Aspergillus niger and Candida albicans.* They were all obtained from the service laboratory of Olabisi Onabanjo University Teaching Hospital, Sagamu, Ogun State.

Methods

Plant collection

Fresh leaves of *A. paniculata* plant were purchased from herb sellers in Sagamu, Ogun State, Nigeria. A voucher specimen with number LUH 6904 was deposited in the herbarium of the Department of Pharmacognosy, Olabisi Onabanjo University. The leaves were thoroughly washed and sun dried for one week. The dried leaves were milled into fine powder with an electric blender and kept in an air-tight container at room temperature.

Preparation of *A. paniculata* extracts

Two hundred gram (200g) of *A. paniculata* powder was macerated in an air-tight sterile jar in 500 ml of either methanol or distilled water for 72 h at room temperature with intermittent shaking. The mixture was filtered with a muslin cloth and the filtrate was concentrated in a rotary evaporator. The dry concentrate, dark brown in colour was packed in clean dry bottle and stored at room temperature.

Qualitative phytochemical screening of *A. paniculata* leaf

Aqueous and methanolic extracts of the leaf were qualitatively screened for the presence of various phytoconstituents (Trease and Evans, 1989).

Formulation of *A. paniculata* cream

The cream formulations were prepared according to the concentration of the ingredients in Table 1. The water soluble ingredients were dissolved in distilled water at a temperature of 70^{o}C to form the aqueous phase while the oil soluble ingredients were also melted at same the temperature to form the oil phase. At the same temperature of 70^{o}C, the aqueous phase was gradually added to the oil phase with moderate and continuous stirring until temperature reduced to 50^{o}C. The emulsion was poured in a cream jar where it set.

Physical properties evaluation

The visual observation of formulation's appearance, colour, homogeneity, texture, and ease of removal were performed according to Arti *et al.,* 2014; Bhide and Nitave,2016; Sekar and Halim, 2017.

Emulsion type determination

Amaranth solution, a water-soluble dye, was mixed with a quantity of the cream. A drop of the cream was placed on a microscope slide, covered with a cover slip and examined using a light microscope - Model CX21FS1, Olympus Corporation . If the dispersed globules are seen to be red under a colourless background, the cream is oil-in-water type and if the condition is reversed, the cream is water-in-oil type. (Arti *et al.*, 2014; Bhide and Nitave, 2016)

pH determination

The pH meter (pH600 pocket sized, Milwaukee) was calibrated to a neutral pH of 7.0 using a standard buffer solution. Five hundred milligrams of formulation was dissolved in 50 ml of distilled water and the pH readings were taken in triplicate (Pandey *et al.*, 2014; Sekar and Halim, 2017).

Viscosity measurement

The viscosities were determined using a Brookfield viscometer (Model - DV - 11 + Pro, Brookfield Eng. Labs Inc Midddleboro, MA, USA) with spindle no. 7. Viscosities were measured at 20, 50 and 100 rpm at 25°C.

Antimicrobial susceptibility testing

A standardized inoculum of each test organism was spread into sterile Mueller Hinton or Sabouraud dextrose agar plates for growth of the organism. A sterile cork borer was used to bore four wells of 6.0 mm in diameter in the agar plates. The cream formulation containing different concentration of the extract was diluted and 0.5mL sample was introduced into the wells using a sterile pipette dropper. The plates were allowed to stand for one hour for diffusion of the samples to take place before incubation at 37^{0}C for 24 hours. Gentamicin and ketoconazole were used as positive control, while the solvent for dilution was used as negative control. The diameter of zones of inhibition produced around the wells was measured to indicate the degree of susceptibility of the test organisms to the sample.

Stability study

The stability of the creams was performed by storing 10g formulation of each cream at 4^{o}C, 25^{o}C, and 50^{o}C for one month. The physical properties were assessed thereafter (Pandey *et al*., 2014; Sekar and Halim, 2017).

Statistical analysis

Statistical analysis was performed with Microsoft Excel 2010 and GraphPad Prism 5. Some data were presented as mean ± standard derivation (SD). Student's *t*-test and ANOVA were used to check significant differences in mean of the parameters evaluated. Differences were considered to be statistically significant at a p value of < 0.05.

Table 1: Code and composition of cream formulations

	Amount of ingredient (%)														
Ingredients	A1	A2	A3	U1	U2	U3	R1	R2	R3	AU1	AU2	AU3	AR1	AR2	AR3
Stearic acid	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Beeswax	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Liquid paraffin	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
A. Paniculata extract	5.0	10.0	20.0	-	-	-	-	-	-	5.0	10.0	20.0	5.0	10.0	20.0
Refined Shea butter	-	-	-	-	-	-	5.0	10.0	20.0	-	-	-	5.0	10.0	20.0
Unrefined Shea butter	-	-	-	5.0	10.0	20.0	-	-	-	5.0	10.0	20.0	-	-	-
Cetyl alcohol	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lanolin	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Glycerin	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Triethanolamine	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Tocopherol	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Distilled water	77.4	72.4	62.4	77.4	72.4	62.4	77.4	72.4	62.4	72.4	62.4	42.4	72.4	62.4	42.4

A1 - 5% of *Andrographis paniculata* extract, A2 - 10% of *Andrographis paniculata* extract, A3 - 20% of *Andrographis paniculata* extract,
R1 - 5% of refined shea butter, R2 - 10% of refined shea butter, R3 - 20% of refined shea butter,
U1 - 5% of unrefined shea butter, U2 - 10% of unrefined shea butter, U3 - 20% of unrefined shea butter,
AU1 - 5% of *Andrographis paniculata* extract + 5% of unrefined Shea butter, AU2 - 10% of *Andrographis paniculata* extract + 10% of unrefined Shea butter, AU3 - 20% of *Andrographis paniculata* extract + 20% of unrefined Shea
AR1 - 5% of *Andrographis paniculata* extract + 5% of Refined Shea butter, AR2 - 10% of *Andrographis paniculata* extract + 10% of Refined Shea butter, AR3 - 20% of *Andrographis paniculata* extract + 20% of Refined Shea

RESULTS AND DISCUSSION

Phytochemical test

The phytochemicals present in both extracts are presented in Table 2 and these are saponins, glycosides, alkaloids, tannins and flavonoids.

Physical characteristics of the creams

The physical characteristics of the cream formulations as presented in Table 3 and Table 4 indicated that all the cream formulations (both aqueous and methanolic extract of *Andrographis paniculata)* were homogenous in appearance, soft, smooth and non-greasy, hence expected to further improve patient compliance.

Emulsion type determination

The emulsion type determination test confirms that all the cream formulations were oil-in-water, thus can be washed off easily from the skin (Arti *et al.,* 2014).

pH of the creams

The pH, a measure of hydrogen ions concentration, is an important factor to be considered in creams and other topical preparations in order to prevent skin irritation from the use of such products. The pH of the skin ranges from 4-7 (Lambers *et al.,* 2013), so topical formulations ideally should be within this range to prevent skin reaction and irritation. The pH of the cream formulations containing aqueous extracts was between 6.2 - 6.8 while formulations containing methanolic extract was between 6 and 7.1. The inclusion of shea butter does not have a remarkable effect on the pH of the creams. All formulations in this study were generally within the pH range of the skin (Lambers *et al.,* 2013).

Table 2: Phytochemical screening of extracts

Phytochemical	Aqueous	Methanol
Anthraquinone	-	-
Saponins	+	+
Glycosides	+	+
Alkaloids	+	+
Tannins	+	+
Flavanoids	+	+

Table 3: Physical properties and pH of the creams (Aqueous extract)

Formulation code	Colour	Texture	Homogeneity	Ease of removal	Emulsion type	pH
A1	Brown	SMN	Good	Easy	o/w	6.5± 0.42
A2	Brown	SMN	Good	Easy	o/w	6.5± 0.18
A3	Brown	SMN	Good	Easy	o/w	6.7± 0.26
U1	Cream	SMN	Good	Easy	o/w	6.2± 0.21
U2	Cream	SMN	Good	Easy	o/w	6.2± 0.10
U3	Cream	SMN	Good	Easy	o/w	6.3± 0.52
R1	Cream	SMN	Good	Easy	o/w	6.5± 0.01
R2	Cream	SMN	Good	Easy	o/w	6.5± 0.11
R3	Cream	SMN	Good	Easy	o/w	6.4± 0.26
AU1	Brown	SMN	Good	Easy	o/w	6.4± 0.13
AU2	Brown	SMN	Good	Easy	o/w	6.2± 0.51
AU3	Brown	SMN	Good	Easy	o/w	6.3± 0.48
AR1	Brown	SMN	Good	Easy	o/w	6.8± 0.13
AR2	Brown	SMN	Good	Easy	o/w	6.8± 0.16
AR3	Brown	SMN	Good	Easy	o/w	6.5± 0.12

SMN =Soft, smooth, non-greasy

Table 4: Physical properties and pH of the creams (Methanolic extract)

Formulation code	Colour	Texture	Homogeneity	Ease of removal	Emulsion type	pH
A1	Brown	SMN	Good	Easy	o/w	6.0± 0.12
A2	Brown	SMN	Good	Easy	o/w	6.1± 0.06
A3	Brown	SMN	Good	Easy	o/w	6.0± 0.02
U1	Cream	SMN	Good	Easy	o/w	6.2± 0.21
U2	Cream	SMN	Good	Easy	o/w	6.2± 0.10
U3	Cream	SMN	Good	Easy	o/w	6.3± 0.52
R1	Cream	SMN	Good	Easy	o/w	6.5± 0.01
R2	Cream	SMN	Good	Easy	o/w	6.5± 0.11
R3	Cream	SMN	Good	Easy	o/w	6.4± 0.26
AU1	Brown	SMN	Good	Easy	o/w	6.5± 0.43
AU2	Brown	SMN	Good	Easy	o/w	6.5± 0.02
AU3	Brown	SMN	Good	Easy	o/w	6.3± 0.14
AR1	Brown	SMN	Good	Easy	o/w	7.1± 0.32
AR2	Brown	SMN	Good	Easy	o/w	6.9± 0.08
AR3	Brown	SMN	Good	Easy	o/w	6.7± 0.22

SMN =Soft, smooth, non-greasy

Viscosity

Viscosity describes the internal resistance of a material to flow and it greatly affects the spreadability of creams and ointments (Oladimeji *et al.*, 2015). The viscosity at spindle speed of 20, 50 and 100 rpm for all the cream formulations are presented in Table 5. Generally, there was a significant decrease in viscosity

as expected with increase in spindle speed. There was no significant difference between the viscosity of the creams containing unrefined and refined shea butter. Although their inclusion significantly increased the viscosity of the formulations containing the extracts of *A. paniculata,* there was no significant difference between the viscosity of formulation containing aqueous extract and those containing methanolic extract.

According to Fishberg, 1930, viscosity is a linear function of the relative volume occupied by the materials in a product. From Table 1, it could be seen that the water content of the formulations reduced as the concentration of the independent variables increased which in turn increased the viscosity of the formulations because the relative volume occupied by the materials in the product had reduced. The incorporation of shea butter increased the viscosity because of its semi-solid nature.

Table 5: Viscosity of the creams at 25ºC

Formulation code	VISCOSITY (centipoise)					
	Aqueous extract			Methanolic extract		
	20rpm	50rpm	100rpm	20rpm	50rpm	100rpm
A1	160	110	90	130	100	70
A2	170	130	100	160	140	110
A3	190	160	110	180	160	120
U1	410	330	240	420	320	250
U2	620	410	320	610	420	340
U3	840	620	520	860	600	510
R1	380	280	180	390	260	180
R2	490	370	220	480	350	220
R3	720	520	410	690	510	420
AU1	680	460	350	660	460	340
AU2	800	540	410	810	550	410
AU3	920	710	620	900	700	620
AR1	400	300	240	420	310	250
AR2	560	390	280	560	380	270
AR3	780	590	470	790	560	460

Antimicrobial susceptibility testing

Test organisms selected were gram positive and gram-negative bacteria, and fungi which are implicated in skin diseases. *Staphylococcus aureus* (gram positive) causes staphylococcal infections such as cellulitis (Ryu *et al.,* 2014; Lawrence and Nopper, 2017), *Pseudomonas aureginosa* (gram negative) causes erythema gangrenosum (Ramakrishnan *et al.,* 2015), *Escherichia coli* **(**gram positive) causes cellulitis (Petkovsek *et al.,* 2009), candida causes candidiasis (Kühbacher *et al.,* 2014; Kashem and Kaplan, 2017) and Aspergillus niger causes aspergillosis (Mohapatra *et al.,* 2009). The antimicrobial activities of aqueous and methanolic extract of *Andrographis paniculata* are presented in Tables 6 (Figure 2) and 7 (Figure 3) respectively. Antimicrobial activity of the all formulations with the positive control was determined by measuring the diameter (mm) of the zone of inhibition on the agar plate. The larger the diameter of the zone of inhibition, the more the extent of activity.

Aqueous extracts did not have any activity against *Pseudomonas aureginosa* at all concentrations but had activity against other test organisms except *candida albicans* where activity occurred only at 20% concentration of *A. paniculata.* Methanolic extracts had activity against all the test organisms at all concentrations except against *Pseudomonas aureginosa* where activity occurred at 10 and 20% concentration only. Creams containing only unrefined shea butter had activity against *Staphylococcus aureus* at all concentrations and on *Aspergillus niger* at 10 and 20% concentrations while creams containing refined shea butter had activity only against *Staphylococcus aureus* at 20% concentration. The incorporation of shea butter (unrefined or refined) in formulations containing aqueous or methanolic extracts of *A. paniculata* enhanced the antimicrobial activity of these formulations. Statistical analysis of formulations containing only aqueous or methanolic extract showed no significant difference in activity against all organisms except for *aspergillus niger* where methanolic extract had more significant activity ($p<0.05$). Formulations containing aqueous or methanolic extract with unrefined or refined shea

butter showed no significant difference in activity against all organisms. Formulations containing unrefined shea butter showed slightly higher activity than refined shea butter though not statistically significant ($p>0.05$). Methanolic extracts showed wider spectrum of antimicrobial activity more than water extract probably because it contained more quantity of tannin, saponin and glycosides, secondary metabolites known to be implicated in the antimicrobial activities of herbs. The result of the antimicrobial activity of *A.* paniculata in this study conformed to previous studies carried out on the plant extract (Das et al., 2014; Najib *et al.*, 2015; Sinha, 2016; Geetha *et al.*, 2017; Narayanaperumal *et al.*, 2018). The positive control had a significantly higher antimicrobial activity than all the cream formulations.

Table 6: Antimicrobial activity of the aqueous extract of Andrographis paniculata

Formulation code	Zone of inhibition (mm)				
	Pseudomonas aureginosa	*Staphylococcus aureus*	*Escherichia coli*	*Aspergillus niger*	*Candida albicans*
A1	-	2± 0.32	2± 0.52	2± 0.22	-
A2	-	4± 0.58	6± 0.12	2± 0.10	-
A3	-	8± 0.40	10± 0.50	5± 0.39	2± 0.38
U1	-	2± 0.00	-	-	-
U2	-	3± 0.02	-	2± 0.01	-
U3	-	5± 0.28	-	4± 0.18	-
R1	-	-	-	-	-
R2	-	-	-	-	-
R3	-	2± 0.10	-	-	-
AU1	-	4± 0.24	3.5± 0.30	3± 0.28	-
AU2	-	6± 0.08	7± 0.14	5± 0.15	-
AU3	-	10± 0.16	12± 0.63	10± 0.24	-
AR1	-	2± 0.14	3± 0.34	2.5± 0.11	-
AR2	-	5± 0.32	7± 0.08	2± 0.04	-
AR3	-	9.5± 0.22	12± 0.25	6± 0.22	3± 0.51
G or K	10± 0.27	20± 0.01	25± 0.20	19± 0.08	22± 0.00

G = gentamicin for bacterial positive control while K = ketoconazole for fungi positive control

Table 7: Antimicrobial activity of the methanolic extract of Andrographis

Formulation code	Zone of inhibition (mm)				
	Pseudomonas aureginosa	*Staphylococcus aureus*	*Escherichia coli*	*Aspergillus niger*	*Candida albicans*
A1	-	5± 0.32	7± 0.52	6± 0.22	2± 0.16
A2	3± 0.19	9± 0.58	13± 0.12	7± 0.10	3± 0.43
A3	7± 0.06	15± 0.40	20± 0.50	10± 0.39	5± 0.38
U1	-	2± 0.00	-	-	-
U2	-	3± 0.02	-	2± 0.01	-
U3	-	5± 0.28	-	4± 0.18	-
R1	-	-	-	-	-
R2	-	-	-	-	-
R3	-	2± 0.10	-	-	-
AU1	-	8± 0.24	8± 0.30	5± 0.28	2± 0.21
AU2	3± 0.12	12± 0.08	13± 0.14	8± 0.15	3± 0.10
AU3	5± 0.31	18± 0.16	19± 0.63	16± 0.24	6± 0.04
AR1	-	5± 0.14	9± 0.34	6± 0.11	2± 0.17
AR2	-	10± 0.32	12± 0.08	6± 0.04	2.5± 0.26
AR3	-	16± 0.22	18± 0.25	11± 0.22	4.5± 0.51
G or K	10± 0.27	20± 0.01	25± 0.20	19± 0.08	22± 0.00

G = gentamicin for bacterial positive control while K = ketoconazole for fungi positive control

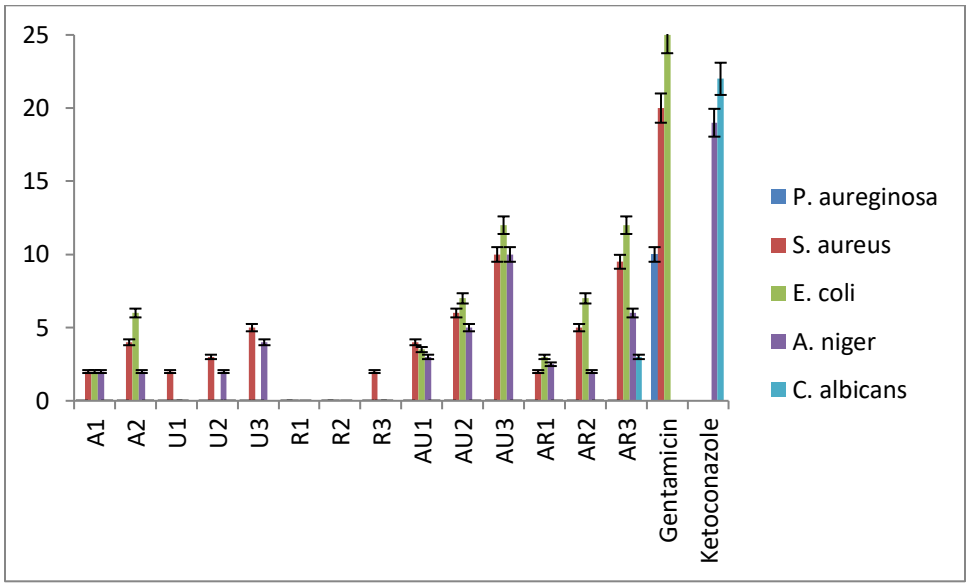

Figure 2: Zone of inhibition of aqueous extract cream formulations

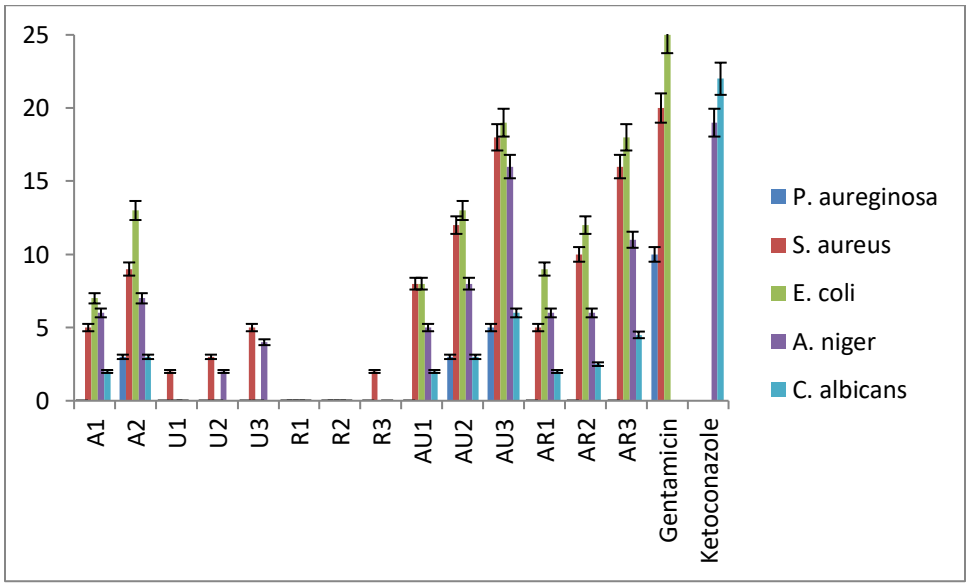

Figure 3: Zone of inhibition of methanol extract cream formulations

Stability study

The physical stability of both methanol and aqueous extract cream formulations evaluated at 4±1°C, 25±1°C and 40±1°C was maintained within the 30 days period used for the accelerated stability studies. All the formulations were stable with no changes in colour, texture, homogeneity and ease of removal from the skin.

CONCLUSION

Inclusion of unrefined and refined shea butter in all the formulations enhanced the antimicrobial activity of *Andrographis paniculata* cream. The methanolic extract exhibited a wider spectrum of antimicrobial activity than the aqueous extract. Formulations containing unrefined shea butter showed a higher activity than refined shea. All the formulations were stable with no changes in colour, texture and homogeneity. This study concludes that *Andrographis paniculata* cream formulated was stable over a range of storage temperature and the antimicrobial activity against some skin damaging pathogens was synergized with the incorporation of shea butter which

compared favorably well with the positive control. Hence it has the potential to be used as a herbal medicated creams against some bacteria and fungi skin infections. However, the compatibility and toxicological evaluation of the formulation should be carried out to ascertain product safety.

REFERENCES

Ajijolakewu, K.A., Awarun, F.J. (2015). Comparative antibacterial efficacy of *Vitellaria paradoxa* (shea butter tree) extracts against some clinical bacterial isolates. Not. Sci. Biol. 7(3): 264-268.

Allen Jr, L.V., Popovich N.G., Ansel H.G. (2010). Ansel's pharmaceutical dosage forms and drug delivery systems (9th Ed) Baltimore: Lippincoil Williams and Wilkins. pp. 720

Ameh, S.J., Obodozie, O.O., Inyang, U.S., Abubakar, M.S., Garba, M. (2010). On the production of conavir® immune-booster by good manufacturing practice: Development of specifications for the herbal component. Afr. J. Pharm. Pharmacol. 4(6): 395-401.

Arti, P., Manish, S., Kalpana, P. (2014). Formulation and evaluation of poly herbal cream. Int. J. Pharm. Bio. Arc. 5(4): 67 – 71.

Balu, S., Alagesaboopathi, C. (1993). Anti-inflammatory activities of some species of *Andrographis* Wall Anc. Sci. Life 13:180–184.

Bhide, M.M., Nitave, S.A. (2016). Formulation and evaluation of polyherbal cosmetic cream. World J. Pharm. Pharm. Sci. 5(1): 1527-1536.

Das, P., Srivastav, A.K. (2014). Phytochemical extraction and characterization of the leaves of *Andrographis Paniculata* for its anti-bacterial, anti-oxidant, anti-pyretic and anti-diabetic activity. Int. J. Innovative Res. Sci. Eng. Tech. 3(8): 15176-184.

Ergene, U., Akcali, Z., Ozbalci, D., Nese, N., Senol, S. (2013). Disseminated aspergillosis due to *Aspergillus niger* in immunocompetent patient: A case report. Case rep in infect dis 2013: 385190.

Fishberg, E.H. (1930). The significance of changes of viscosity in pathological sera. J. Biol. Chem. 85:465-475.

Geetha, I., Catherine, P., Alexander, S. (2017). Antibacterial activity of *Andrographis paniculata* extracts. The Pharma Innovation Journal 6(5): 01-04.

Hong T.D., Linington S., Ellis R.H. (1996). Seed storage behavior: a compendium. Handbook for Genebanks: No. 4 International Plant Genetic Resources Institute, Rome, Italy.

Jarukamjorn, K., Kondo, S., Chatuphonprasert, W., Sakuma, T., Kawasaki, Y., Emito, N. (2010). Gender-associated modulation of inducible CYP1A1 expression by andrographolide in mouse liver. Eur. J. Pharm. Sci. 39: 394–401.

Kashem, S.W., Kaplan, D.H. (2016). Skin immunity to *Candida albicans.* Trends. Immunol. 37(7): 440–450.

Kühbacher, A., Burger-Kentischer, A., Rupp, S. (2017). Interaction of candida species with the skin. Microorganisms 5(2): 32.

Lambers, H., Piessens, S., Bloem, A., Pronk H., Finke P. (2006). Natural skin surface pH is on average below 5, which is beneficial for its resident flora. Inter. J. Cosmet. Sci. 28: 359-370

Lawrence H.S., Nopper M.J. (2017). Superficial bacterial skin infections and cellulitis: In Long S.S., Prober C.G., Fischer M. (eds). Principles and Practice of Pediatric Infectious Diseases. Elsevier, Canada. pp. 427-435.

Maranz S, Kpikkpi W, Weisman Z, Sauveur A D, Chapagain B (2004). Nutritional values and indigenous preferences for shea fruits (*vitellaria paradoxa*) in African agroforestry parklands. J. Eco. Botany 58: 588 -600.

Mohapatra, S., Xess, I., Swetha, J.V., Tanveer, N., Asati, D., Ramam, M., Singh, M.K. (2009). Primary cutaneous aspergillosis due to *Aspergillus niger* in an immunocompetent patient. Indian J. Med. Microbiol. 27(4): 367-70.

Najib, Y.., Wan-Azemin, A., Dharmaraj, S., Suryati, K. (2015). Phytochemical Screening and prophylactic antibacterial effects of *Andrographis Paniculata* extracts from kemaman, malaysia. J. Nat. Sci. Res. 5(16): 67-72.

Narayanaperumal, R., Raj, H.P., Govindan, R., Karasala, B.R., Garapati, R. (2018). Antimicrobial and phytochemical studies of *Andrographis paniculata* (Burm.f.) Wall. ex Nees and *Andrographis echioides* (L.) Nees. Int. J. Life Sci. Res. 6(3): 334-341.

Oladimeji, F.A., Akinkunmi, E.O., Raheem, A.I., Abiodun, G.O., Bankole, V.O. (2015). Evaluation of topical antimicrobial ointment formulations of essential oil of *lippia multiflora* moldenke. Afr. J. Tradit. Complement Altern. Med. 12(5):135-144.

Pandey, S., Seth, A., Tiwari, R., Singh, S., Behl, H.M., Singh, S. (2014). Development and evaluation of antimicrobial herbal cosmetic preparation. Afr. J. Pharm. Pharmaco. 8(20): 514-528.

Petkovsek, Z., Elersic, K., Gubina, M., Zgur-Bertok, D., Erjavec, M.S. (2009). Virulence potential of *Escherichia coli* isolates from skin and soft tissue infections. J. Clinical. Microbiol. 47(6): 1811–1817

Polash, S.A., Saha, T., Hossain, M.S., Sarker, S.R. (2017). Investigation of the phytochemicals, antioxidant, and antimicrobial activity of the *andrographis paniculata* leaf and stem extracts Adv. Biosci. Biotech. 8(5): 149-162.

Ramakrishnan, K., Salinas, R.C., Higuita, N.A. (2015). Skin and soft tissue infections. Am. Fam. Physician 92(6):474-483.

Ryu, S., Song, P.I., Seo, C.H., Cheong, H., Yoonkyung, P.Y. (2014). Colonization and infection of the skin by *S. aureus*: immune system evasion and the response to cationic antimicrobial peptides. Int. J. Mol. Sci. 15(5):8753-722

Sekar, M., Halim, F.H. (2017). Formulation and evaluation of natural anti-acne cream containing *Syzygium samarangense* fruits extract. Annual Res. Rev. Bio. 17(3): 1-7.

Sheeja, K., Shihab, P.K., Kuttan, G. (2006). Antioxidant and anti-inflammatory activities of the plant *Andrographis Paniculata* Nees. Immunopharmac. and Immunotox. 28(1): 129-140.

Sinha, N. (2016). Phytochemical and antimicrobial study of *Andrographis paniculata* Nees. Int J Adv. Sci. Res. 1(7): 10-12.

Trease A., Evans W.C. (1989). Pharmacognosy (13th Ed) Balliene Tindiall, London. pp. 62-74.

*Address for correspondence: Olutayo A. Adeleye

Department of Pharmaceutics and Pharmaceutical Technology,
Olabisi Onabanjo University, Ago Iwoye,
Ogun State, Nigeria.

Telephone: + 234-8033784449

E-mails: olutayoadeleye@yahoo.com

Conflict of Interest: None declared

Received: 21 May, 2019

Accepted: 18 June, 2019