An Experimental Study to Determine the Antibacterial Activity of Selected Petroleum Jellies against Selected Bacteria that cause Skin Infections.

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Abstract

Background:
The skin is the largest organ of the body and forms its first line of defence against pathogens. When the integrity of this natural protective barrier is compromised, it's an opportune moment for pathogenic microorganisms such as *Pseudomonas aeruginosa, Staphylococcus aureus, Streptococcus pyogenes* among others to invade the body causing skin infections such as folliculitis, acne, impetigo among others.

Objectives:
This study aimed at determining the phytochemical profile of the selected petroleum jellies, determining the antibacterial activity of different petroleum jellies on selected bacteria causing skin infections, comparing the antibacterial activity of the jellies to that of the commonly used drugs against skin infections, and determine the minimum inhibitory concentration (MIC) of the jellies exhibiting antibacterial activity.

Methods:
The antibacterial activity of the jellies was determined by agar well diffusion method (AWD) and the minimum inhibitory concentration (MIC) was determined by broth dilution method.

Results:
Only herbal jellies exhibited antibacterial activity against at most two of the three bacterial species studied. The MIC values for the herbal jellies ranged from 47 mg/ml to 188 mg/ml.

Conclusion:
The non-herbal petroleum jellies did not show antibacterial activity while that of herbal jellies was minimal with very low potency and thus should not be relied on for wound healing or curing skin infections.

Recommendations:[a]
The antibacterial activity of jellies should be tracked diligently to detect and address antimicrobial resistance as it arises to ensure that they remain efficacious.

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1 Background

The skin is the largest organ of the body and forms its first line of defence against pathogens. It plays a number of vital roles which include the fore mentioned protection, thermal regulation, excretion, and detection of environmental stimuli in the surrounding.

Skin supports the growth of commensal bacteria, which protect the host from pathogenic bacteria both directly and indirectly; directly, bacteria, for example, *Staphylococcus aureus* strain 502A release bacteriocins that inhibit other virulent staphylococcal organisms, production of toxic metabolites, depletion of essential nutrients, prevention of adherence of competing bacteria, inhibition of translocation, and degradation of toxins.

Indirectly, bacteria can induce the host to enhance antibody production, stimulate phagocytosis and clearance mechanisms, in addition to augmenting interferon and cytokine production. For example, Propionibacterium acnes release fatty acids from lipid breakdown, acidifying the milieu and inhibiting the growth of *Streptococcus pyogenes*[4].

The skin's natural micro flora includes species of *Corynebacterium, staphylococci, streptococci, Brevibacterium,* and Candida as well as Propionibacterium. Gram-negative organisms such as *Pseudomonas aeruginosa, Pasteurella multocida, Capnocytophaga canimorsus, Bartonella sp.*, and *Klebsiella rhinoscleromatis*, are not typical resident skin microflora but may cause cutaneous infection[12].

However, this enormously protective body organ is not without challenges, in the event of skin trauma such as burns, ulcer, scratch, or tearing, the integrity of this natural protective barrier is compromised, which provides an opportune moment for pathogenic microorganisms such as *Pseudomonas aeruginosa*, *Staphylococcus aureus, Streptococcus pyogenes* among others to invade the body causing septicaemia and skin infections such as folliculitis, acne, impetigo among others.

A number of studies have indisputably asserted that the three organisms, namely; *Pseudomonas aeruginosa, Staphylococcus aureus,* and *Streptococcus pyogenes* are the major cause of bacteria related skin infections[29].

Examples of skin infections include; impetigo, cellulitis, folliculitis, furunculitis, and carbanculosis caused by *Staphylococcus aureus,* and Ecthyma, dermal erysipelas and blistering distal dactylitis caused by *Streptococcus pyogenes*[12].

While skin diseases are widespread especially in developing countries, little attention has been accorded to them. They have often been overlooked and disregarded as a public health concern[31]. Although skin infections have little impact on mortality, the morbidity that results has a great impact on the quality of life, especially if it involves disfigurement or disability[25].

The persuasive advertisement by petroleum jellies' manufacturers in Uganda has convinced people that such petroleum jellies have the potential to cure skin infections, which has ramified into their use to treat and manage wounds, often resenting the recommended drugs on market.

Almost every homestead in Uganda uses petroleum jellies daily with the conviction that these jellies have the potential to protect them against or cure skin infections. Often in every homestead, most family members share the same jelly container and control of the risk of transmission of contagious skin diseases will largely depend on the antimicrobial potential of these jellies.

Surprisingly, not so many studies to date have investigated the efficacy of skin care products, a few studies have investigated medicated soaps. For example, Riaz, Ahmad, & Hasnain[26], demonstrated that *Pseudomonas aeruginosa* and *Klebsiela pneumoniae* exhibited resistance against antibacterial soap. The same study showed that antibacterial soaps such as life buoy, safe guard and Dettol liquid hand wash had better inhibitory and bactericidal effects on commonly encountered bacteria compared to beauty soaps such as Lux soap, Palmolive and Capri soaps.

A study carried out in Pakistan by Abbas et al[1], also showed that medicated soaps such as Dettol have antibacterial activity against Staphylococcus aureus, and that the antibacterial activity increased with an increase in the concentration of the soap solution.

According to a review study by Muirhead[21] , petrolatum-based based ointments as efficacious as antibiotic ointments in the healing of clean wounds and that recent studies have shown that the use of antibacterial ointments in the ambulatory surgical population does not decrease the risk of infection.

Topical skin infections have often been treated through topical application of antibiotic creams

such as cefalexin, neomycin, Gentamycin and fluconazole, antibacterial ointments such as bacitracin or Neosporin, or a petrolatum-based ointment such as Aquaphor to provide a semi-occlusive barrier[21].

Oral antibiotics such as erythromycin, tetracycline, and dicloxacillin are used to treat many skin conditions[29]. Certain mainstream companies are incorporating natural ingredients, such as honey into their products and thus it is important to determine the best usage for such components Mierzejewski[19], and Dinkov et al[8].

Additionally, Royal jelly, Royal honey, or a 1:100 combination of both was shown to inhibit the growth of Methicillin Resistant *Staphylococcus aureus* (MRSA) at concentrations of 20%, 30%, and 40%w/v in Tryptic soy broth[8].

The study aims to determine the antibacterial activity of some of the commonly used petroleum jellies against selected bacteria causing skin infections in comparison with the antimicrobial drugs used to treat skin infections in Uganda.

2 Materials and methods

Ethical consideration

This study was neither a human nor an animal research study, it was an experimental study only involving characterized and archived microbial isolates obtained from the microbiology laboratory of Mulago National referral hospital Kampala. As a result it was exempted from ethical clearance by the Ethical Review Board of the College of veterinary medicine animal resources and biosecurity (COVAB) of Makerere University Kampala.

2.1

2.1.1 Study design

This was an experimental study to determine the antibacterial activity of the different petroleum jellies; Baby Junior (Movit products Ltd, Uganda), Samona (SAMONA PRODUCTS (U) Ltd), Movit (herbal) (Movit products Ltd, Uganda), Skin Doctor (Dama Medicinal herbs, Kampala (U) Ltd), and Vaseline (Blue seal) (Unilever Kenya Ltd), against selected bacteria causing skin infections.

The study was conducted between May and July, 2018 in the Veterinary Pharmaceutical and toxicology Research Laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity (CoVAB), Makerere University. The study involved a collection of known and characterized bacterial isolates from Mulago hospital; microbiology laboratory, Screening the jellies for antibacterial activity by agar well diffusion assay (AWDA) and establishing the minimum inhibitory concentration (MIC) of the jellies against the selected bacterial isolates.

The jellies were purchased from Mega standard supermarket located along Burton Street; opposite Old taxi park, Kampala, Uganda. Five commonly used jellies in Uganda as named above were obtained from the above outlet as a trusted source selling such products. The jellies were selected to include three herbal jellies and two non herbal jellies. Thereafter, they were transported to the Veterinary Pharmaceutical and Toxicology Research Laboratory for analysis.

Three bacterial organisms; *Staphylococcus aureus, Pseudomonas aeruginosa*, and *Streptococcus pyogenes* commonly involved in skin infections were obtained from the microbiology laboratory of Mulago National referral hospital, kampala (Uganda), emulsified in sterile 50% glycerol and Tryptic Soy Broth (TSB) and then transported on ice to CoVAB, Veterinary Pharmaceutical and toxicology Research Laboratory where they were maintained at -20∘C before analysis.

2.1.2 Inclusion and exclusion criteria

Only bacterial strains that were confirmed to be *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Streptococcus pyogenes* by colony characteristics and then biochemical tests were included in this study. Only jellies whose expiry date was at least 12 months ahead were used in this study.

2.1.3 Determination of phytochemicals in herbal jellies.

The phytochemicals in the herbal jellies were determined qualitatively by mixing specified quantities of the respective jelly solutions with the test reagents and then observing for any colour changes, or changes in the nature of the mixture such as; formation of a precipitate or foam to draw conclusion on the presence or absence of a Phytochemical. The procedures and expected observations are summarised in appendix 1.

2.1.4 Preparation of jellies for analysis

Each of the five jellies; Baby Junior (Movit products Ltd, Uganda), Samona (SAMONA PRODUCTS (U) Ltd), Movit (herbal) (Movit products Ltd, Uganda),

Skin Doctor (Dama Medicinal herbs, Kampala (U) Ltd), and Vaseline (Blue seal) (Unilever Kenya Ltd), were prepared by weighing 5g of each petroleum jelly and dissolved in 10ml of 70% acetone (500mg/ml), shaken well until it dissolved to make test solutions of concentration 50%w/v.

2.1.5 Preparation of culture media

Mueller Hinton agar (biotech, UK), which is recommended for carrying out antimicrobial susceptibility tests for rapidly growing organisms such as; *Pseudomonas aeruginosa* and Staphylococcus aureus was used together with Nutrient agar. All media plates were prepared in the Microbiology laboratory of Mulago national referral hospital and aseptically transported to the Veterinary Pharmaceutical and toxicology Research Laboratory, CoVAB.

2.1.6 Preparation of nutrient agar

Nutrient agar was prepared according to the manufacturer's (Laboratorios Conda, South Africa) instructions.

2.1.7 Preparation of Mueller Hinton agar

Mueller Hinton agar (MHA) used for sensitivity was prepared according to the manufacturer´s (Laboratorios Conda South Africa) instructions. The MHA plates were quality controlled using *Escherichia coli* (ATCC 25922) with Gentamycin, Nitrofurantoin, Nalidixic acid, and ceftazidime Oxoid (UK), and *Staphylococcus aureus* (ATCC 25923) with vancomycin, tetracycline, and oxacillin Oxoid (UK).

2.1.8 Preparation of 0.5 McFarland Standard according to Becton and Dickinson, 2010

A respective 24hour old cultures of the test organisms were produced to obtain a standard inoculum. 10ml of a 0.5 McFarland standard was prepared to which the turbidity of the test microorganisms was compared. The 0.5 McFarland standard was prepared by adding 0.05ml (50μl) of 0.048M Barium Chloride to 9.95ml (9,950 μl) of 0.18M Sulfuric acid to obtain 10ml (10,000μl). Then to 5ml of sterile 0.9% normal saline, colonies of each of the test microorganisms were added until the turbidity of the saline matched that of the McFarland standard. Noting that 0.5 McFarland standard inoculum was approximately 1.5 X 10^8 CFU/ml (Becton and Dickinson, 2010).

2.1.9 Determination of antimicrobial activity of jellies using agar diffusion assay

10 μl of the standardized respective bacteria were inoculated on the surface of Mueller Hinton agar plates (Oxoid) by surface spreading to obtain a uniform inoculum. After this, 3 wells of 5mm diameter and 4mm depth were cut into the solid agar using a sterile agar borer. 50μl of the test petroleum jellies solutions of concentration 0.5g/ml were dispensed in the wells[1].

Three other wells were cut into separate plates to include two more jelly samples and a negative control well to which 70% acetone[11] was added to ascertain that there was no antibacterial activity due to the solvent (negative control). Discs of positive control of Cotrimoxazole, Chloramphenicol, Amoxicillin/Clavulanic acid combination, and Gentamycin; Oxoid (UK) were inserted in a separate plate for each of the three organisms. These tests were repeated four times to ensure reproducibility of results.

The plates were incubated aerobically at 37^{o}C for 24 h. Following incubation, the diameter of any zone of inhibition was measured using a ruler and a pair of dividers and the results were reported in millimeters.

2.1.10 Determination of the minimum inhibitory concentration

Minimum inhibitory concentrations for the jellies that exhibited antibacterial activity were determined. The minimum inhibitory concentration (MIC) of each of the jellies was determined by the broth dilution method. The jellies were serially diluted with sterile distilled water (Laboratorios Conda, South Africa) in 2-folds up to a concentration of 0.03125g/ml.

A turbidity standard for inoculation (0.5 McFarland standard) was prepared. This was followed by diluting the adjusted inoculum suspension in broth so that each tube contained approximately 5 x 10^5 CFU/ml. The 0.5 McFarland suspension was also diluted in the ratio of 1:150. Consequently, 1 ml of test bacteria (1 x 10^6 CFU/ml) was added to the tubes containing 1 ml of the respective jelly solution in each of the tubes, and the positive control tube which contained 1ml of broth instead of the jelly solution. A negative control tube which contained 1ml of distilled water, 1ml of broth was also

set up, the tubes were then covered with sterile cotton and incubated at 37°C overnight (García, Finola, & Marioli, 2010).

Finally, the visual turbidity for each tube was recorded, from which the MIC was obtained. As previously stated, the minimum inhibitory concentration was defined as the lowest concentration of an antimicrobial agent that inhibits the growth of microorganisms after an overnight incubation.

3 Data analysis

Both descriptive and inferential approaches were used. The raw data was entered and analyzed using SPSS version 25. The mean, standard error of the mean, maximum, minimum and standard deviation of the zones of inhibition for the jellies were determined at a statistical significance of 95%.

4 Results

4.1

4.1.1 Phytochemical profile and chemical profile of the herbal petroleum jellies

Flavonoids, steroids, and Triterpenoids were found in the three herbal petroleum jellies. Meanwhile, phenolic compounds were found in Samona herbal jelly only.

4.1.2 The antibacterial activity of petroleum jellies against selected bacterial isolates.

Only Movit and Samona had antibacterial activity against at most two of the tested microorganisms, with Movit having activity on *Staphylococcus aureus* and *Streptococcus pyogenes* whereas Samona had activity on *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Only Movit herbal jelly had antibacterial activity against Streptococcus pyogenes while only Samona had antibacterial activity against *Pseudomonas aeruginosa*. None of the non-herbal petroleum jellies had antibacterial activity.

Basing on the zones of inhibition of the petroleum jellies against the tested organisms, Samona herbal jelly exhibited the highest activity with a mean inhibition zone of diameter 22.25mm against *Staphylococcus aureus.*

Samona also exhibited the least, although exclusive antibacterial activity against *Pseudomonas aeruginosa* with a mean zone of inhibition at 9.25mm.

Staphylococcus aureus and *Streptococcus pyogenes* were susceptible to the five antibacterial drugs that were used as positive controls as well as for comparison of the antibacterial activity on jellies. Meanwhile, *Pseudomonas aeruginosa* was susceptible to only tetracycline and Gentamycin. All tested organisms were susceptible to Gentamycin.

Comparison of the antibacterial activities of Movit, herbal and Samona to Amoxicillin/Clavulanic acid against *Staphylococcus aureus*

Since the 95% confidence intervals of the zones of inhibition for Movit and Samona included zero, the mean zone of inhibition for the two jellies may not be different from that of amoxicillin/ clavulanic acid.

Thus, *Staphylococcus aureus* is equally susceptible to the petroleum jellies as it is to Amoxicillin/ Clavulanic acid. The differences between the means were not statistically significant since the p-values are >0.05.

4.1.3 Comparison of the antibacterial activity of Movit herbal with that of Tetracycline against Streptococcus pyogenes.

The antibacterial activity of Movit herbal against *Streptococcus pyogenes* was different from that of Tetracycline since the 95% confidence interval did not include zero. The antibacterial activity of Movit herbal was lower than that of tetracycline against *Streptococcus pyogenes*. The difference between the means was statistically significant since the p-value was less than 0.05.

Comparison of the antibacterial activity of Samona herbal petroleum jelly with that of Gentamycin against *Pseudomonas aeruginosa.*

The antibacterial activity of Samona herbal jelly against *Pseudomonas aeruginos*a was lower than that of Gentamycin against the same microorganism. The difference in antibacterial activity was statistically significant since the p-value was less than 0.05.

Table 1. Phytochemicals in the Herbal petroleum jellies; Skin doctor, Movit and Samona

Phytochemicals	Chemical test	Movit herbal jelly	Samona Herbal jelly	Skin Doctor jelly
Alkaloids	Hager's test	+	+	_
Flavonoids	Alkaline reagent test	+	+	+
Phenolic compounds	Lead acetate test	_	+	_
Tannins	Lead acetate test Ferric chloride test	_	_	_
Steroids and Triterpenoids	Salkowski's test	+	+	+
Saponins	Froth test	_	_	_
Cardiac glycosides	Keller-killiani test	_	_	_

Key: +=Present and - = Absent

Table 2. Antibacterial activity of the petroleum jellies and positive controls against selectedbacteria causing skin ifections

		Staphylococcus aureus	*Pseudomonas aeruginosa*	*Streptococcus pyogenes*
Mean zones of inhibition (mm ± S.E)	**Positive controls (drugs)**	20.0 (TE)	25.0 (GE)	32.0 (TE)
	Samona herbal jelly	22.25 ± 1.65	9.25 ± 0.56	0.0
	Movit herbal jelly	21.5 ± 1.71	0.0	14.0 ± 0.82

KEY:
±: Plus or minus, mm: millimeter, S.E: Standard error, TE: Tetracycline, GE: Gentamycin

Table 3. Comparison of antibacterial activities of Movit herbal and Samona herbal petroleum jellies to Amoxicillin/Clavulanic acid against *Staphylococcus aureus*

	Test Value = 24					
	t	df	p-value	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Zones of inhibition of movit herbal against Staphylococcus aureus in millimetres	-1.464	3	0.239	-2.50000	-7.9351	2.9351
Zones of inhibition of Samona against Staphylococcus aureus in millimetres	-1.059	3	0.367	-1.75000	-7.0075	3.5075

Key: t: Test statistic, df: Degrees of freedom

Table 4. Comparison of the antibacterial activity of Movit herbal petroleum jelly with that of Tetracycline against *Streptococcus pyogenes.*

	Test Value = 32					
	t	df	p-value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Zones of inhibition of movit herbal against *Streptococcus pyogenes* in millimetres	-22.045	3	0.000	-18.00000	-20.5985	-15.4015

Key: t: Test statistic, df: Degrees of freedom

Table 5. Comparison of the antibacterial activity of Samona herbal jelly against *Pseudomonas aeruginosa* with that of Gentamycin.

	Test Value = 25					
	t	df	p-value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Zones of inhibition of Samona against *Pseudomonas aeruginosa* in millimetres	-14.206	3	0.001	-15.75000	-19.2783	-12.2217

Key: t: Test statistic, df: Degrees of freedom

4.1.4 Minimum Inhibitory Concentration (MIC) of petroleum jellies against selected bacterial species.

Minimum inhibitory concentration (MIC) was determined for only the petroleum jellies that exhibited antibacterial activity in the former experiments.

The MIC values for the two petroleum jellies; Movit and Samona ranged from 47 mg/ml to 188 mg/ml, with Samona having the highest MIC at 188mg/ml against *Pseudomonas aeruginosa.* Movit herbal and Samona herbal jellies were mostly effective against *Staphylococcus aureus* given the lowest MIC (47 mg/ml) observed with the petroleum jellies.

5 Discussion:

This study aimed at determining the antibacterial activity of a few selected petroleum jellies commonly used in Uganda against selected bacteria known to cause skin infections. The phytochemicals and chemical profile of the jellies was determined as recommended by Orchard & Vuuren[23]. No similar study investigating the antibacterial activity of commercial products such as soap and jellies was found to determine the phytochemicals or chemical profile as was observed in the studies by; Riaz et al[26]., García, Finola, & Marioli[13], Eloff[11], and Sharquie et al[27]., possibly because these studies were carried out before that by Orchard & Vuuren[23].

Phytochemical composition varied among the herbal jellies and so did the chemical profile of the nonherbal jellies. This could be as a result of using extracts from different plants, or extracts from different plant structures as phytochemical composition was shown to vary between or among plants, plant structures of the same plant and with the method of extraction by; Orchard & Vuuren[23], Hill & Leaves[15], and Lorenzo[16], thus variation in antibacterial activity. Benzene compounds constitute the largest proportion of the non-herbal jellies, possibly because they are largely petroleum products with minimal additives.

Antibacterial activity was observed in two of the three herbal jellies investigated, on at least two of the three bacterial species. None of the non-herbal jellies exhibited antibacterial activity. This contradicted with the studies in the review by Muirhead[21], which asserted that petrolatum-based ointments were as efficacious as antibiotic ointments in the healing of clean wounds but were partly congruous

Table 6. Minimum inhibition concentration (MIC) in mg/ml of Movit and Samona herbal jellies against *Staphylococcus aureus, Streptococcus pyogenes,* and *Pseudomonas aeruginosa.*

Name of the petroleum jelly	*Staphylococcus aureus*	*Pseudomonas aeruginosa*	*Streptococcus pyogenes*
Movit herbal	47	0.00	94
Samona herbal	47	188	0.00

with findings by Riaz, Ahmad, & Hasnain[26], which showed that antibacterial soaps such as life buoy, safe guard and Dettol liquid hand wash had better inhibitory and bactericidal effects on commonly encountered bacteria compared to beauty soaps such as Lux soap, Palmolive and Capri soaps. This could be due to variations in phytochemical composition qualitatively or quantitatively.

The observed lack of antibacterial activity in non-herbal jellies could be due to lack of active components with such activity or being in concentrations well below their minimum inhibitory concentrations.

The antibacterial activity of Movit and Samona herbal jellies against *Staphylococcus aureus*, and the exclusive activity of Samona against *Pseudomonas aeruginosa* can be attributed to the presence of alkaloids in both jellies unlike in skin doctor herbal jelly which did not exhibit antibacterial activity, as was similarly shown by Lorenzo[16], that an alkaloid extract exhibited antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa.* The exclusive antibacterial activity of Samona against *Pseudomonas aeruginosa* can be attributed to the possibly higher concentration of alkaloids in Samona than in movit herbal jellies or Samona could be containing a different type of alkaloid compared to that in Movit herbal jelly as Lorenzo[16], demonstrated that different alkaloids have varying antibacterial activity against *Pseudomonas aeruginosa.*

Overall, the antibacterial activity of the herbal jellies was either equal to or less than that of the commonly used antimicrobial drugs. This finding was contra to that by Hill & Leaves[15], where extracts of Eucalyptus globulus Labill and Corymbia ficifolia containing phenolic compounds exhibited antibacterial activity higher than standard antibiotics Gentamycin and ciprofloxacin against Staphylococcus aureus with a MIC value of 20 μg/ml for Corymbia ficifolia extract.

There was no significant difference between the antibacterial activities of movit, Samona herbal jellies and amoxicillin/Clavulanic acid. This could be because the active compounds in the jellies were similar to those in the antibiotics as some antibiotics have been manufactured from plant extracts as attested by Martin & Ernst[18].

The antibacterial activity of movit herbal jelly against *Streptococcus pyogenes* was significantly lower than that of tetracycline. This could be because some of the active compounds in tetracycline are not in the jelly or are in concentrations well below their minimum inhibitory concentration. Similarly, the antibacterial activity of Samona herbal jelly was significantly lower than that of gentamycin.

The minimum inhibitory concentration of movit herbal jelly against *Streptococcus pyogenes* was 94 mg/ml while that against *Staphylococcus aureus* was 47 mg/ml. The minimum inhibitory concentration of Samona herbal jelly was 47 mg/ml and 188mg/ml against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, respectively. This implies that the active compounds in the jellies had minimal antibacterial activity against the microorganisms. These were contra to the study by Hill & Leaves[15], where extracts of Corymbia ficifolia containing phenolic compounds exhibited antibacterial activity against *Staphylococcus aureus* with a MIC value of 20 μg/ml.

Pseudomonas aeruginosa was the most resistant bacteria with the highest MIC of Samona herbal jelly (188mg/ml). This finding was similar to that of Riaz et al[26]., where the same organism was the most resistant to antibacterial soap. This could be an evident resistance to common active compounds usually incorporated into products such as herbal soap and jellies.

6 Conclusions and recommendations

7 Conclusion

The non-herbal jellies did not have antibacterial activity against the selected bacterial strains and thus should not be relied on for wound healing or curing skin infections. The antibacterial activity of herbal jellies namely; Samona and movit was minimal with very high minimum inhibitory concentrations, which implied that a lot of it should be applied at the infected site to achieve the desired effect (low potency).

The herbal petroleum jellies had a narrow spectrum of antibacterial activity as they were each able to exhibit antibacterial activity against at most two of the three tested organisms. Additionally, the antibacterial activity of jellies was either lower or equal to that of the commonly used antimicrobial drugs, yet at high concentrations of jellies. Therefore, in the meantime, drugs should remain the cornerstone of the treatment of wounds and skin infections until more natural plant extracts that have been assayed and their antibacterial potential ascertained are added to the jellies.

7.1

7.1.1 Recommendations:

Plant extracts with significantly high antibacterial potential and broad spectrum of antibacterial activity such as those recommended by Orchard & Vuuren[23], and those cited in this study should be included as fundamental components of jellies if they are to have antibacterial activity.

The antibacterial activity of jellies should be tracked diligently to detect and address antimicrobial resistance as it arises to ensure that they remain efficacious.

The Phytochemical composition of the herbal petroleum jellies should be quantified and the correlation between antimicrobial activity and concentration of the phytochemicals drawn. This will help ascertain which Phytochemical is responsible for which antimicrobial activity and in which concentrations.

Other petroleum jellies and ointments or lotions should be investigated to ascertain their antimicrobial potential. The jellies whose antibacterial activity was determined in this study can be further investigated on other microorganisms of clinical significance, especially those involved in wounds and skin infections as well as the normal flora of the skin.

8 Funding for this study:

The study was individually fully funded by the corresponding author. No external source of funding was obtained from any individual for the accomplishment of this study.

Conflict of interest:

The study was carried out in an entirely independent atmosphere without influence from any of the jelly manufacturers or sellers. This ensured minimal bias in the experimental procedures and thus the findings of the study.

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This research study was done as part of my undergraduate academic requirements at Makerere University, Kampala – Uganda, and as a result a copy of the original research dissertation can be accessed in the university dissertations repository through the link below;

http://dissertations.mak.ac.ug/handle/20.500.12281/4869?show=full

10 LIST OF ABBREVIATIONS AND ACRONYMS

%	Percentage
&	And
(U)	Uganda
<	Less than
>	Greater than
≤	Less than or equal to
≥	Greater than or equal to
μg	micrograms
μl	Micro liter
BBLT	Bachelor of Biomedical Laboratory Technology
CAM	Complementary and alternative medicine

Cfu/ml Colony forming units per mil liter
df Degrees of freedom
et al and others
$FeCl_3$ Iron (III) chloride
g Grams
GC-MS Gas chromatography mass spectrometry
H_2SO_4 Sulphuric acid
hrs Hours
Ltd Limited
MDR Multi drug resistant
mg/ml Milligrams per milliliter
MHA Mueller Hinton Agar
MHB Mueller Hinton Broth
MIC Minimum Inhibitory Concentration
ml Milliliter
mm Millimeter
MRSA Methicillin resistant Staphylococcus aureus
°C Degrees Celsius
rpm Revolutions per minute
sig Significance
TSB Tryptic Soy Broth
v/v Volume per volume
VRSA Vancomycin Resistant Staphylococcus aureus
w/v Weight per volume
WHO World Health Organization
XDR Extensively drug resistant

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Appendix: 1

Table 7. biochemical tests

Phytochemicals	Procedure	Observation
Alkaloids	3 drops of each of the Jelly solutions were dissolved individually in dilute hydrochloric acid and filtered. Filtrates were treated With Hager's reagent.	Formation of yellow-coloured precipitates indicated the presence of alkaloids.
Flavonoids	To 3 drops of each of the test solutions, a few drops of sodium hydroxide solution were added.	Formation of intense yellow colour which turns to colorless by addition of a few drops of dilute acetic acid indicated the presence of flavonoids.
Phenolic compounds	To 3 drops of each of the test solutions, a few drops of 10% lead acetate solution were added.	Formation of white precipitate indicated the presence of phenolic compounds.
Tannins	To 3 drops of each of the test solutions, a few drops of 10% lead acetate solution were added	Precipitate formation indicated the presence of tannin.
Steroids and Triterpenoids	3 drops of each of the jelly solutions were treated with chloroform and filtered. The filtrates were treated with few drops of conc. Sulphuric acid shaken well and allowed to stand.	Appearance of red colour in the lower layer indicated the presence of steroids. Formation of reddish brown colour of the interface after addition of conc. Sulphuric acid on the side carefully (without shaking) indicated the presence of Triterpenoids
Saponins	To 3 drops of each of the jelly solution was added to 2-3 ml of distilled water. The mixture was shaken vigorously.	Formation of foam indicated the presence of saponins.
Cardiac glycosides	To 3 drops of each of the test solutions, 2ml of glacial acetic acid containing a few drops of $FeCl_3$ solution was added. 1ml of conc. H_2SO_4 was added along the side of the test tube carefully.	A brown ring at the interface indicated the presence of deoxysugar of cardenoloides. A violet ring may appear beneath the brown ring, while In the acetic acid layer, a greenish ring may also form just gradually throughout the layer.