ORIGINAL PAPER

https://dx.doi.org/10.4314/njpr.v21i1.3

Nig. J. Pharm. Res. 2025, 21(1) pp 23-32
ISSN 0189-8434 e-ISSN 2635-3555
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Available online at http://www.nigjpharmres.com

Evaluation of Formulated Herbal Lozenges of *Pavetta crassipes* and *Anogeissus leiocarpus* Leaf Extracts for Treatment of Cough

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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: Medicinal plants are a vital healthcare component, particularly in regions where access to conventional medicine is limited. The study aims is to formulate lozenges containing dried hydro-alcohol extracts of leaves of *Pavetta crassipes* and *Anogeissus leiocarpus* and evaluate their physico-mechanical properties, antimicrobial efficacy and cough-suppressing ability in laboratory mice.

Methods: Hydro-alcoholic extracts of the plants were evaluated for their pharmacological efficacy using ammonia-induced cough model in albino mice, antimicrobial susceptibility testing against selected microorganism and acute toxicity. Four batches of hard lozenges containing 0 % extract, 10 % of either extract and combination of both extracts at 5 % each were prepared and labelled L1, L2, L3, L4 respectively. The lozenges were evaluated for physico-mechanical properties. Pharmacological efficacy of the lozenges in cough suppression was determined in albino mice. Antimicrobial susceptibility of the lozenges was also evaluated against selected micro-organisms.

Results: The lozenges had characteristic odor, sticky texture, and moderately sweet to moderately bitter taste. All the batches had uniform weights ranging between 1.43 and 1.68 g, hardness was between 15.98 and 25.24 kgF and friability was < 1 %. Moisture content was low (0.79 and 1.10 %) and dissolution time was between 9- and 11-min. Antimicrobial susceptibility was more significant with formulations L2 and L4 while cough suppression effect was most significant with L4 (88.61 %).

Conclusion: This study presents a promising natural alternative for management of cough, potentially reducing the heavy reliance on synthetic drugs and offering a sustainable, culturally integrated approach to healthcare.

Keywords: *Pavetta crassipes*, *Anogeissus leiocarpus*, lozenges, antimicrobial susceptibility, cough suppression

INTRODUCTION

Medicinal plants play a crucial role in healthcare systems, particularly in regions where access to conventional medicine may be limited or where cultural practices favor traditional remedies. There has been a growing recognition of herbal medicine on a global scale, with about 65 - 85 % of population relying on plants for medicinal purposes (Manzo *et al*., 2017) and this significantly influences both public health and international trade. This has promoted extensive research worldwide into the development of diverse herbal formulations which are as beneficial as the existing synthetic formulations.

Cough is a prevalent symptom associated with various respiratory conditions and poses a significant health challenge (Madison and Irwin, 2010). It can result from infections, environmental irritants, allergies, asthma, medications like ACE inhibitors and second-hand exposure to smoke exposure (Kahrilas *et al.,* 2016). Therapeutic interventions are often used to address the underlying cause of cough or treat the symptoms associated with cough. Natural remedies like honey, lemon and ginger have been found effective in dealing with cough and other respiratory diseases. Studies have shown that plant extracts can also soothe cough symptoms due to anti-inflammatory and mucus-thinning properties (Kruttschnitt *et al*., 2020).

In Nigeria, *Pavetta crassipes* and *Anogeissus leiocarpus* have been used traditionally to alleviate cough, excessive phlegm, and sore throat (Bariweni and Ozolua, 2017). *Pavetta crassipes*, Family; Rubiaceae, is widely distributed across tropical savannah regions of West and East Africa, including countries like Benin, Ghana, Niger, Nigeria and Cameroon (Katsayal and Abdurahman, 2002). In Nigeria, the plant is known as "Gadu" in Hausa, "Lubobo" in Yoruba, and "Nkor" in Igbo. Leaves of *Pavetta crassipes* is used traditionally in Northern Nigeria to manage respiratory disorders and symptoms associated with respiratory infections (Bello *et al*., 2011). The plant, *Anogeissus leiocarpus*, commonly called Axle-wood tree, belongs to the Combretaceae family and is widely distributed in West Africa, Ethiopia and East (Adekunle *et al*., 2024). In Nigeria is called “Marke” in Hausa, “Ka’ayin” in Yoruba and “Atara” in Igbo. Traditionally, decoction of the bark is used to treat cough and its symptoms (Arbab *et al*., 2014).

Extracts of *Pavetta crassipes* and *Anogeissus leiocarpus* have shown activity against mycobacterium infections and respiratory tract pathogens (Hadiza *et al*., 2022). Antioxidant properties of the plants have been reported to contribute to respiratory protection diminishing the severity and recurrence of cough episodes (Baldé *et al.,* 2020).

Lozenges are flavored medicated dosage forms intended to be dissolved or disintegrated in the mouth or pharynx containing one or more medicaments usually in a sweetened base (Datri *et al.,* 2023). The formulation of lozenges offers a promising approach to cough management, as they provide targeted relief to affected areas in the respiratory tract, effectively soothing irritation and suppressing cough reflexes.

The aim of this study therefore, is to formulate herbal lozenges containing leaf extracts of *Pavetta crassipes* and *Anogeissus leiocarpus*, evaluate the physical and mechanical properties of same and assess the potential of the formulated lozenges in suppressing cough bouts in laboratory animals.

METHODOLOGY

Collection and authentication of plant materials

Leaves of test plants; *Pavetta crassipes* and *Anogeissus leiocarpus* were collected by an authorized herbarium staff; Mr. Muazam of the National Institute for Pharmaceutical Research and Development (NIPRD) Abuja. They were identified and authenticated at the herbarium unit of NIPRD, Abuja and given voucher numbers; NIPRD/H/7409 and NIPRD/H/7440 respectively.

Preparation of leaf extracts of *Pavetta crassipes* and *Anogeissus leiocarpus*

Leaves of *Pavetta crassipes* and *Anogeissus leiocarpus* were individually dried under shade conditions for 7 days. Powdered leaves of each plant were individually macerated in 70 % aqueous methanol for 24 h and 72 h respectively. Afterwards, the mixtures were filtered using muslin cloth and concentrated to dryness over a water bath at 70 °C. The final dried products were packaged in airtight containers, labelled as PC and AL respectively and kept in a desiccator.

Formulation of herbal lozenges of PC and AL

The technique of melting and molding was used to prepare hard candy lozenges. Corn syrup (16.9 mL), sugar (22.5 g) and distilled water (7.5 mL) were heated to about 150 °C until a bright yellow color was obtained. The resulting mixture was poured into cells

of the lozenge mold and left for 30 min at room temperature to cool. The lozenges were removed from the mold and the average weight of all lozenges was determined. Composition of ingredients for preparation of lozenges are presented in Table 1. Appropriate amount of sugar was melted in a stainless-steel bowl then water was added to the melted sugar while stirring until the sugar dissolved. Corn syrup was added into the bowl and heated to about 150 °C with intermittent stirring until the mixture became bright yellow in color. Where PC and AL were required to be incorporated, the bright yellow mixture was allowed to cool for about 30 sec before the extract was stirred into it to obtain a homogenous mix. The mixture was poured into the lozenges mold, left to cool and harden at 28 ºC. The lozenges were removed from the cells and individually wrapped in foil paper, placed in a dispensing envelope, labelled appropriately and kept in a desiccator until further use.

Table 1: Composition of Herbal Lozenges Containing PC and AL

Ingredients/formulation	L1	L2	L3	L4
PC (g)	-	-	5.35	2.675
AL (g)	-	5.35	-	2.675
Sugar (g)	22.50	22.50	22.50	22.50
Corn syrup (mL)	16.90	13.05	13.05	13.05
Water (mL)	7.50	7.50	7.50	7.50

Antimicrobial susceptibility testing of prepared extracts

Typed cultures used include *Staphylococcus aureus* NCTC 6571, *Escherichia coli* ATCC 11775, *Pseudomonas aeruginosa* 27853, *Streptococcus pyogenes* ATCC 1238, *Salmonella enteritidis* ATCC 14025, *Klebsiella pneumoniae* ATCC BAA 1705 and *Proteus* mirabilis. Dilutions of extracts were made using 20 % Tween 20 in sterile distilled water to achieve concentrations of 40 and 20 mg/mL. Hundred microliters (100 µL) of the different concentrations were dispensed into bored holes on Muller Hinton agar seeded with 0.5 Mc Farland suspensions of test microorganisms and incubated at 37 °C for 24 h (CLSI, 2021). Ciprofloxacin disc (10 µg) was used as positive control. The zones of inhibition were measured appropriately.

Acute toxicity testing of prepared extracts

The mice were housed under ambient conditions (temperature 24 ± 2 ºC; 12 h light/dark cycle). They were fed with standard rodent meal and given drinking water ad libitum. The protocol of the study was approved by the Animal Care and Ethics Committee of Department of Pharmacology and Toxicology, NIPRD, Abuja (NIPRD/05:03:05-54 dated September 12, 2024). Acute oral toxicity study was conducted according to OECD Test Guideline 420 (OECD, 2023). Sixteen (16) albino mice of either sex (27 - 30 g) grouped into four animals per group (n=4) were used. The animals were fasted for 12 h but allowed free access to water. Suspension of each extract in water and a single dose of 2000 mg/kg was administered to the mice *via* oral gavage. Behavior of the animals was observed 30 min post-administration, monitoring was continued hourly for next 4 h and daily for 14 days.

Antitussive efficacy of prepared extracts

The ammonia-induced cough model as earlier described by Uwaya *et al*., (2023) was adopted. Thirty-two (32) albino mice of both sexes were used; the animals were assigned to eight groups of four mice each (n=4) and treated as such:

Group I: Administered 1 mL of distilled water; Group II: Administered 1 mL of 800mg/kg dose AL; Group III: Administered 1mL of 400mg/kg dose AL; Group IV: Administered 1 mL of 200mg/kg dose AL; Group V: Administered 1 mL of 800mg/kg dose PC; Group VI: Administered 1 mL of 400mg/kg dose PC; Group VII: Administered 1 mL of 200mg/kg dose PC; Group VIII: Administered 1 mL of 5mg/kg dose Dihydrocodeine (DHC)

The animals were fasted for 12 h before administration of treatment. After 30 min of treatment the mice were exposed to 25 %w/w ammonia liquor in closed chamber for 1 min and the number of cough bouts was noted over a 5 min observation period. Percentage of cough suppression was calculated based on the difference in cough bouts between treated and control groups.

Organoleptic evaluation of prepared lozenges

The color, odor, shape, texture and taste of the lozenges were determined using the sensory organs.

Determination of lozenges weight

Ten (10) lozenges randomly selected from each batch were individually weighed using an analytical balance. The average weight and standard deviation were calculated.

Determination of thickness and diameter

The thickness and diameter (mm) of ten (10) randomly selected lozenges from each batch were determined using a digital vernier caliper.

Determination of hardness

Hardness of five (5) lozenges from each batch were determined using the Monsanto hardness tester, the mean and standard deviation were subsequently calculated.

Determination of friability

Five (5) lozenges from a batch were collectively weighed, placed into the Erweka Friabilator and set to rotate at 25 rpm for 4 min. Afterwards, the lozenges were re-weighed and percentage loss in weight was calculated.

Determination of specific gravity

One (1) lozenge was weighed, placed in 5 mL of distilled water in a beaker and observed until it completely dissolved. The final volume of mixture after immersion was recorded and specific gravity was calculated as a ratio of the weight of lozenges to the final volume (Udem and Adikwu*,* 2024).

Determination of moisture content

One (1) lozenge from each batch was weighed and placed in a hot air-oven (LEEC, UK) maintained at 60 ℃ for 6 h. Afterwards, the lozenges were weighed; moisture content was calculated as ratio of the difference in weight to initial weight before being placed in the oven (Srujan and Sriram, 2019).

Determination of dissolution time

One (1) lozenge was placed in phosphate buffer at pH 6.8 (100 mL) in a beaker which was placed on a hot plate maintained at 37 ℃ and mechanically stirred at 50 rpm. The time taken for the lozenge to dissolve completely was recorded (Lakshmi *et al*., 2017).

Determination of pH

One (1) lozenge from each batch was dissolved in distilled water (1 % w/v) at room temperature. The pH of the mixture was determined using digital pH meter (Mettler Toledo). Two more determinations were performed; the average and standard deviation were calculated.

Antimicrobial susceptibility of prepared lozenges

A 24 h culture of test microorganisms grown in tryptic soy broth at 37 °C was prepared, 1 mL of culture was transferred to 20 mL of sterile molten Mueller-Hinton Agar previously cooled to 45 °C. The mixture was poured into sterile plates, allowed to solidify, then 4 wells were aseptically bored into the agar using sterile cork borer. Dissolved lozenges (100µg) were introduced into the wells, the plates were incubated accordingly (Daoud *et al*., 2015).

Evaluation of cough-suppressing effects of prepared lozenges

Mice were randomly assigned to 5 treatment groups (n=5). One lozenge from each batch was dissolved in distilled water and 1 mL was administered at a dose of 150 mg/kg to each mouse. One (1) hour after treatment, the mice were exposed to 25 %w/w ammonia liquor in a closed chamber for 1 min, the number of cough bouts was noted over a 5 min observation period. Percentage of cough suppression was calculated based on the difference in cough bouts between treated and control groups.

Group I: Administered 1 mL distilled water; Group II: Administered dissolved blank lozenges (150 mg/kg); Group III: Administered dissolved lozenges containing AL (150 mg/kg); Group IV: Administered dissolved lozenges containing PC (150 mg/kg); Group V: Administered dissolved lozenges containing combination of AL and PC (150 mg/kg).

Statistical analysis

Three (3) determinations were made for each parameter and results were expressed as mean ± standard error of mean (SEM). Statistical comparisons were performed by one-way analysis of variance (ANOVA), followed by Dunnets post-hoc test. Data was analyzed by using Statistical Package for the Social Sciences (SPSS, version20.0). A P-value less than 0.05 was considered significantly different.

RESULTS

Results of antimicrobial susceptibility of extracts on selected microorganisms shows the zone of inhibition (mm) of both extracts at 20 mg/mL and 40 mg/mL against selected microorganisms (Table 2). Inhibitory effects of the extracts on the microorganisms were observed to increase with increasing concentration. Higher concentrations of the extracts produced more significant inhibitory action than lower concentrations. AL at 40 mg/mL showed the highest inhibitory effect across all concentrations and extract type.

Acute toxicity of the extracts showed no mortality at test dose of 2000 mg/kg of either extract in any of the groups of animals. However, animals that received PC displayed signs of tremors excessive rearing, while those that received AL exhibited writhing and sedation within the period of observation.

The effect of various concentrations of extracts in suppressing cough in mice is presented in Figure 1. Higher concentrations of either extract resulted in greater cough suppression than when lower doses were administered. Administration of PC at 800mg/kg resulted in more significant cough suppression than AL and the effect was similar that of DHC (5mg/kg).

Organoleptic properties of the formulated lozenges highlight variations in color, odor, shape, taste and texture (Table 3). Lozenges weight, thickness, diameter, hardness, friability, specific gravity, moisture content, pH and dissolution time are displayed in Table 4. Average weight was similar across batches but higher in L1 (batch without extract). Thickness and diameter were similar across the batches. Formulation L3 had the least hardness while L2 exhibited the highest hardness and friability was least in formulation L2.

Table 5 displays the zone of inhibition of selected micro-organisms against the prepared lozenges. Formulation L1 had no activity against the micro-organisms whereas, L2 exhibited more significant antimicrobial activity than L3. However, L4 showed the most significant effectiveness against the microorganisms.

In Figure 2, cough suppression was observed to be highest (about 88 %) with administration of formulation L4 followed by L2 with about 77 % suppression while L3 exhibited about 67 % suppression and blank lozenges (L1) showed the least suppression (about 58 %).

Table 2: Antimicrobial Susceptibility of Extracts on Selected Microorganisms at Different Concentrations

Microorganism	PC (20 mg/mL)	PC (40 mg/mL)	AL (20 mg/mL)	AL (40 mg/mL)	+ CTRL
Staphylococcus aureus NCTC 6571	8.0	15.0	9.0	24.0	20.0
Escherichia coli ATCC 11775	10.0	14.0	13.0	25.0	20.0
Pseudomonas aeruginosa 27853	9.0	16.0	11.0	23.0	22.0
Proteus mirabilis	0.0	12.0	0.0	11.0	20.0
Streptococcus pyogenes ATCC 12384	7.0	11.0	13.0	26.0	21.0
Klebsiella pneumonia ATCC BAA 1705	9.0	15.0	13.0	17.0	20.0
Streptococcus pneumonia ATCC 9533	9.0	15.0	15.0	24.0	19.0

+ CTRL – positive control

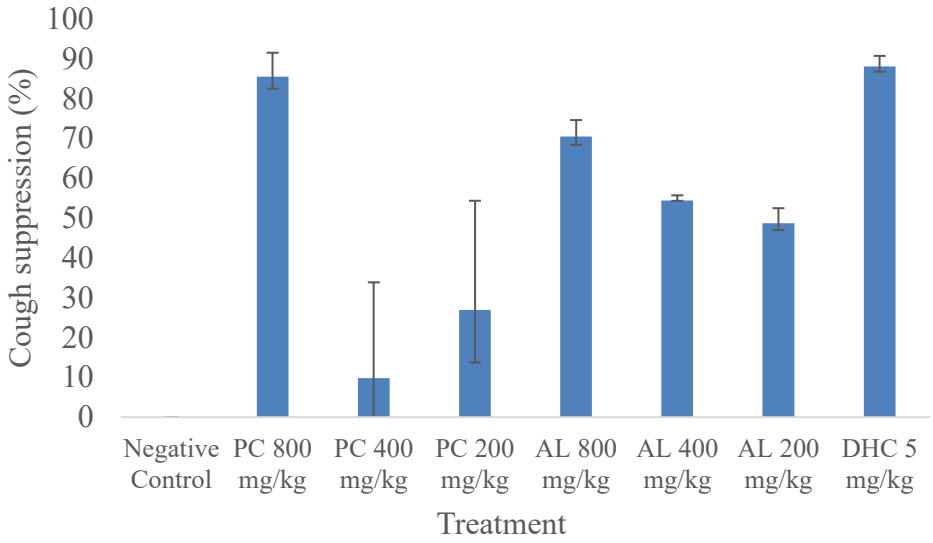

Figure 1: Effect of various concentrations of *Pavetta crassipes* and *Anogeissus leiocarpus* extracts in suppressing cough in mice.

Table 3: Organoleptic Evaluation of Different Batches of Lozenges

Parameter	L1	L2	L3	L4
Color	Bright Yellow	Dark Brown	Coffee Brown	Light Brown
Odor	Sugar Smell	Coffee Smell	Herbal Smell	Herbal Smell
Taste	Sweet	Moderately sour	Moderately sour	Moderately sour
Shape	Semi-Circle	Semi-Circle	Semi-Circle	Semi-Circle
Texture	Smooth	Rough	Smooth	Rough

Table 4: Physico-chemical Properties for Different Batches of Lozenges

Parameter	L1	L2	L3	L4
Weight (g)	1.63 ± 0.15	1.48 ± 0.09	1.53 ± 0.05	1.43 ± 0.03
Thickness (mm)	11.07 ± 0.46	10.95 ± 0.34	10.56 ± 0.21	10.92 ± 0.16
Diameter (mm)	12.45 ± 0.19	12.69 ± 0.03	12.36 ± 0.19	12.58 ± 0.11
Hardness (kgF)	25.02 ± 0.16	25.24 ± 0.80	15.98 ± 1.08	24.10 ± 0.83
Friability (%)	0.61	0.22	0.36	0.59
Specific gravity (g/mL)	0.27	0.25	0.26	0.25
Moisture content (%)	0.79	0.86	1.10	0.82
pH	7.04 ± 0.03	6.46 ± 0.04	6.30± 0.03	6.81 ± 0.08
Dissolution time (min)	12.00 ± 1.99	11.00 ± 1.81	9.00 ± 1.51	11.00 ± 1.88

Table 5: Zone of Inhibition (mm) of Micro-Organisms Against Prepared Lozenges

Microorganism	L1	L2	L3	L4
Staphylococcus aureus NCTC 6571	0.00	20.00	10.00	20.00
Escherichia coli ATCC 11775	0.00	20.00	8.00	14.00
Pseudomonas aeruginosa 27853	0.00	0.00	8.00	20.00
Proteus mirabilis	0.00	20.00	13.50	22.00
Streptococcus pyogenes ATCC 12384	0.00	11.00	10.00	12.00
Klebsiella pneumonia ATCC BAA 1705	0.00	20.00	10.00	21.00
Streptococcus pneumonia ATCC 9533	0.00	22.00	0.00	14.50

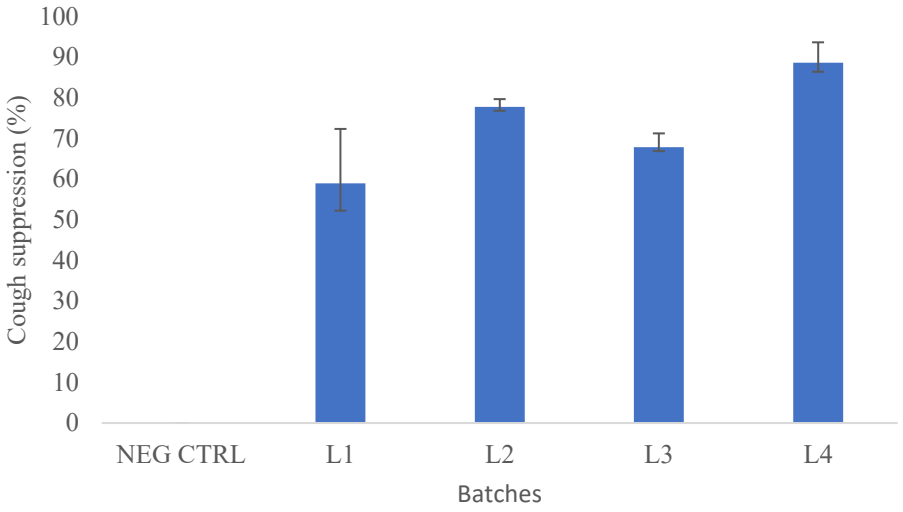

Figure 2: Effect of the prepared lozenges in suppressing cough in mice.

DISCUSSION

Antimicrobial susceptibility testing determines the minimum inhibitory concentration and zones of inhibition for different extracts (CLSI, 2021). Significance of these tests lies in their ability to inform clinical decisions regarding the use of natural compounds as alternatives to conventional antibiotics, especially in light of increasing microbial resistance. The microorganisms were more susceptible to AL at 40mg/mL than to other extracts or Ciprofloxacin (the positive control). The activity of these extracts can be associated with the presence of some secondary metabolites like alkaloids and tannins which have been documented to possess antimicrobial properties. Our findings align with some existing literature which reports similar zones of inhibition with PC (Hadiza *et al*., 2022) and with AL (Muhammad *et al*., 2022).

Understanding the safety profile of plant materials is important for standardization and effectiveness, it helps determine the maximum tolerated dose and establishes a safety margin for their application in medicine. Administration of the extracts did not produce any mortality at dose of 2000 mg/kg per oral, suggesting that the LD_{50} of both extracts may be greater than 2000 mg/kg. However, signs of tremors and excessive rearing were observed with administration of PC which have been reported previously in a toxicity study (Bariweni *et al*., 2018). Conversely, administration of AL produced writhing and sedation which were also observed in previous studies (Adamu *et al*., 2022). This suggests that ingestion of AL or PC may require caution.

Cough suppression was observed to be dose dependent; increasing dose of the extracts produced more reduction in cough bouts because more of the extracts was made available for action. PC at 800 mg/kg produced the most significant reduction ($p<0.05$) in cough bouts which was comparable to Dihydrocodeine but produced higher suppression than that of AL at the same dose. The study by Esievo *et al*., (2023) postulated that the presence of significant levels of flavonoids and tannins in *Pavetta crassipes* is responsible for its anti-inflammatory and cough-suppressing properties. Lower doses of AL produced better cough suppression than corresponding doses of

PC at $p<0.05$ as have also been documented by Adekunle *et al*., (2024).

All the lozenges were semi-circular in shape, formulation L1 containing no extracts had bright yellow color, sweet taste, sugary smell and smooth texture. Lozenges containing extracts (L2, L3 and L4) had different shades of brown color depending on the color of extracts, characteristic herbal smell, were moderately sour with rough texture. The results suggest the need for further refinement of the formulations containing extracts to improve its sensory properties which will impact patient's acceptability and compliance.

All the lozenges had uniform weights with minimal variations within the batches (USP, 2011) this consistency in weight shows the lozenges contain uniform amount of extracts. This is important because variability in weight can affect dosing accuracy and therapeutic effectiveness.

Thickness is a crucial physical property of lozenges that directly affects their dissolution rate and mouthfeel which is a factor in patient compliance; thicker lozenges may be perceived as uncomfortable, potentially decreasing treatment adherence (Rahul *et al*., 2024). Determination of diameter on the other hand is an essential parameter for packaging purposes; non-uniform weights of dosage forms would affect the quantities that can be fitted into the primary packaging container (Olayemi and Nock, 2021). There was no significant difference ($p<0.05$) in the thickness and diameter of the lozenges across batches.

Hardness test is essential for assessing the mechanical integrity of lozenges. Higher hardness value indicates better resistance to breaking and deformation, which is critical for maintaining the lozenge's shape during storage and transport. Formulation L1 exhibited the highest hardness which can be attributed to hardening of sugar and corn syrup. Addition of AL did not significantly increase hardness of the lozenges however; addition of PC significantly reduced hardness and could be attributed to the sticky nature of PC which affects strength of the bonding between particles (Schleuniger, 2011). Friability evaluates resistance to abrasion or fraction during transportation, storage and use (Kumar *et al*., 2019). All batches had low friability (< 1 %) indicating they possessed sufficient strength for use, transportation and storage. Low friability is vital for patient compliance, as lozenges that crumble easily can lead to poor user experience and inconsistent dosing.

Specific gravity provides insight into the density of formulations which can impact disintegration and dissolution. Higher specific gravity results in slower dissolution rates, which can be advantageous for prolonged therapeutic effects but not beneficial if immediate release is intended. Conversely, lozenges with lower specific gravity dissolve more rapidly, providing quicker relief (Udem & Adikwu, 2024). There was no significant difference ($p<0.05$) in specific gravity across batches which underscores optimization of the preparation technique.

Moisture content was similar for formulations L1, L2 and L4 but was highest for L3 containing PC and can be attributed to the sticky nature of the extract. The presence of high oil or sugar content in extracts can cause moisture retention while resin-based extracts might result in drier lozenges due to lower moisture retention (Datri *et al.,* 2023).

The pH can affect the taste of the lozenge, and an optimal range is necessary to enhance the user experience. The ideal pH for lozenges is neutral to slightly acidic to avoid unpleasant sourness, which could deter use (Chanda & Nallaguntla, 2020). Formulation L1 had neutral pH; incorporation of AL and PC led to a significant drop (at $p<0.05$) in pH with formulation L3 containing PC having the lowest pH. However, pH of formulation L4 was higher than those of L2 and L3 but not significantly different ($p<0.05$) from L1. All the lozenges had pH within acceptable ranges for lozenges which supports stability and patient acceptability (Sanjeevani *et al*., 2023).

Mouth-dissolving time is crucial for assessing how quickly a lozenge releases its active ingredients. Rapid dissolution is desirable for lozenges aimed at providing quick relief from symptoms such as cough or sore throat. Complete mouth-dissolving time was similar for L1, L2 and L4 while L3 demonstrated the fastest dissolution time. When quicker therapeutic effects are intended, faster dissolution is preferred however, some studies suggest that herbal lozenges generally have longer dissolution times than non-herbal lozenges, which can be beneficial for ensuring sustained therapeutic effects (Choursiya & Indurkhya, 2020).

Antimicrobial efficacy ranked in the order L2>L4>L3>L1. The selected micro-organisms were significantly susceptible to lozenges containing AL and the combination of AL and PC than PC alone. L1 showed no activity against any of the tested organisms because of the absence of the extract. Inhibitory effects of L2 were similar to that of L4 and this suggests the formulations exhibited broad-spectrum activity

against selected micro-organisms. L3 exhibited only minimal inhibitory effects which were significantly different from those of L2 and L4 ($p<0.05$).

Cough suppression was more significant with formulation L2 than L3 at $p<0.05$ while L4, containing the combination of both extracts exhibited the most significant cough suppression effect which can be attributed to synergistic effect of both extracts. Therefore, combination of AL and PC in lozenges formulation has potential therapeutic outcomes in suppressing cough bouts and managing cough.

CONCLUSION

In this study, herbal lozenges containing dried hydro-alcohol leaf extracts of *Pavetta crassipes* and *Anogeissus leiocarpus* were successfully prepared. Lozenges formulation containing the combination of both extracts at 5 %w/w concentration each was the most efficient in inhibiting growth of microorganisms. Synergistic effect of both extracts also produced the most significant cough suppression. The outcome of this study supports the traditional use in management of cough and reveals the potential of developing a novel formulation for cough suppression or management.

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Conflict of Interest: None declared
Received: May 16, 2025
Accepted: June 5, 2025