



Arctium lappa root extract based emulgels attenuate inducible cytokines and prostaglandins formation: Potential in the management of chronic inflammatory disorders

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ABSTRACT

Background: Chronic inflammation contributes significantly to the burden suffered in many disease conditions in Africa with modern treatments often inaccessible to many. Phytotherapy presents a useful way to accelerate access to Universal health coverage with minimal incurred costs. The study was aimed at exploring the in vitro anti-inflammatory action and formulation of *Arctium lappa* root, a plant grown and available in different regions in Africa, as an herbal emulgel for the management of chronic inflammation

Methods: Methanol root extract of *Arctium lappa* (0.25, 0.50 and 1.00 % w/w) was used for pre-formulation analysis. Phytochemical screening of the extract was done using the Harborne's standardized method for phytochemical analyses. In vitro anti-inflammatory activity was studied by evaluating inhibitory actions of the extracts on Prostaglandin-E (PGE), tumour necrotic factor- α (TNF- α) and cyclooxygenase II (COX-2) using Enzyme-Linked Immunosorbent Assay. Post formulation, the percentage inhibition of the pro-inflammatory cytokines by the herbal emulgels were compared with commercial diclofenac emulgel. The physicochemical properties of the herbal emulgels were also determined.

Results: The preliminary qualitative phytochemical analysis of *Arctium lappa* root extract gave tannins, saponins, phenolics, steroids, glycosides, flavonoids, anthocyanin, terpenoids, and alkaloids as its contents. The extract's inhibitory activities on PGE-2, COX-2 and TNF- α were dose dependent. The formulated herbal emulgel showed that the activities of PGE-2, COX-2 and TNF- α were significantly inhibited in comparison with vehicle-treated control. The physical appearance (which reflected the concentration gradient of the *Arctium lappa* root extract in the emulgels), consistency and homogeneity of the emulgels were acceptable and spreadable. The pH and viscosity of the emulgels were from 4.97 ± 0.04 to 5.42 ± 0.05 and 3.36 ± 0.40 and 3.95 ± 0.50 Pas, respectively.

Conclusion: Here, the emulgel of *Arctium lappa* root extract showed promising anti-inflammatory property evidenced in its ability to attenuate PGE-2, COX-2 and TNF- α activities in-vitro, which was similar to the effect of diclofenac (a currently used anti-inflammatory agent of synthetic origin). This study is novel, important and of great impact because it provides a useful indication

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of *Arctium lappa* as a topical agent in the management of chronic inflammatory disorders. As compared to previous studies, key advances in this research include the first successful attempt to formulate the root extract of *Arctium lappa* into an emulgel, advancing the application of pharmaceuticals in phytotherapy for prospects of improved treatment of inflammation, especially in Africa; and this can be adapted globally beyond the region.

Background

Chronic inflammation plays significant roles in various debilitating diseases which include vascular disorders, cancer, neurodegenerative and inflammatory diseases of autoimmune origin, that often affect acquired and innate immune systems [1]. Interestingly, in these events, non-steroidal anti-inflammatory drugs (NSAIDs) inhibit cyclooxygenase-2 (COX-2) and suppress prostaglandins (PGD₂, PGE₂, PGF_{2α}) production. PGs are expressed in the tissues either constitutively or inducible and involved in the generation of inflammatory mediators. More so, inducible COX-2 isoform, is often highly expressed in tissues of chronic disorders [1]. Inflammation becomes chronic when acute inflammation is not resolved within 24 h because the negative feedback mechanisms responsible for resolution has been inhibited, thus, amplifying inflammatory responses including sustained release of pro-inflammatory cytokines at sites of inflammation. It is well reported that NF-κB are synergistically activated by PGs and cytokines to induce the expression of inflammation-related genes, co-opting COX-2 involved in the positive feedback loop mediated by PG. Hence, the expression of various NF-κB-induced genes including chemokines is enhanced by signaling to neutrophils and macrophages, leading to the cells being infiltrated and chronic inflammation amplified [1].

The use of natural products in the treatment of diseases is as old as mankind. Natural products are affordable, readily available, and safe [2]. Hence, natural products are being increasingly used for the treatment of painful and inflammatory conditions globally [3,4]. *Arctium lappa* (Asteraceae) or burdock is utilized in Africa, Asia, North America, and Europe for the treatment of chronic inflammatory conditions including rheumatoid arthritis, sore throat, rashes, boils, and cancer [3,5]. Zarei et al. [6] reported the benefit of *A. lappa* in the management of pain experienced in rheumatoid arthritis. NSAIDs are the most commonly prescribed medications for chronic inflammations but they are linked with several adverse effects including gastrointestinal disturbance and dermatitis. Therefore, the need for better and affordable treatment options still exists. Despite the many benefits associated with gel use, its main constraint is the inability to deliver drugs that are hydrophobic [7,8]. To put a check on this, an emulsion formulation strategy is being adopted, where the successful addition of hydrophobic therapeutic moiety to the gels ensures improved delivery. A mixture of either the oil-in-water or water-in-oil type of emulsion and gelling agent gives an emulgel. Moreover, the formulation scientist can regulate the appearance, viscosity, and level of greasiness of emulsion-based cosmetics and dermatological products. The evaluation of the anti-inflammatory effect of *Arctium lappa* root extract emulgel preparation was done in this study.

Materials and method

Materials used

Methanol, ethanol, span 20, liquid paraffin, tween 20, ethyl paraben, methyl paraben, triethanolamine, glutaraldehyde, and propylene glycol were procured from BDH Chemicals Ltd (Poole England), dimethylsulfoxide (DMSO) and carbopol 940 were purchased from Guangdong Chemical Reagent, (Guangdong, China) while mentha oil and clove oil were commercially obtained from Ashifaul-Haqi Ltd. (Nigeria). Anti-inflammatory assay kits (COX-2, PGE, and TNF-α enzyme linked immunosorbent assay kits) and the human recombinant type of pro-inflammatory mediators were obtained from Cayman Chemical, Ann Arbor, MI, USA.

Collection and treatment of plant materials

Roots of *Arctium lappa* were collected, identified, and authenticated at the Department of Plant Biology Herbarium, University of Ilorin. UILH/001/2019/1398 was assigned as the voucher number. Air-drying of the roots was carried out for 14 days at room temperature. The roots were then milled into smaller pieces and kept in a dry glass jar for extraction.

Extraction of *Arctium lappa* root

Five hundred grams of the pulverized roots of *Arctium lappa* was macerated in 80 % w/v methanol and left for 72 h. This was followed by decanting, and the process was repeated three times for exhaustive extraction. A rotary evaporator was used to concentrate the filtrate, followed by oven-drying. A specimen bottle was used to store the dried extract until needed.

Pre-formulation evaluation of extract

Physical evaluation of extract

The physical properties of *Arctium lappa* extracts were examined, and this included colour, odour and texture.

pH measurement of extract

The pH values of *Arctium lappa* extracts were determined using a calibrated digital pH meter (Hanna, UK). The probe of the pH meter was dipped into the undiluted extract at room temperature. pH readings were taken after stabilization of display. The pH measurements were repeated in triplicates.

Phytochemical analysis of extract

Qualitative analysis. Qualitative analysis of the extract was determined using standard procedures as described in literature [9–11]. Saponins, tannins, phenolics, phlobatannin, steroids, flavonoids, coumarins, anthocyanin, amino acid, terpenoids, glycosides, tri-terpenes, alkaloids, and fixed oils were all tested for in the extract. The presence or absence of any the phytochemicals was recorded and the results of qualitative assay formed the basis on which the quantitative phytochemical analysis was designed and done.

Quantitative analysis. Informed by the results of the qualitative analysis, phytochemical constituents detected in the extract were assayed quantitatively. Saponin, tannin, phenolics, steroids, flavonoids, anthocyanin, terpenoids, glycosides, and alkaloids were quantitatively assessed using the Harborne's method [9] and by spectrophotometry [12]. The concentration of each phytochemical constituent was recorded in mg/100 g (except terpenoids and glycosides that were recorded in ug/100 g).

Screening of extract for anti-inflammatory activities

In vitro anti-inflammatory activity was studied by evaluating at graded concentrations the inhibitory actions of the extracts and 1 % w/w diclofenac (as positive control) on COX-2, PGE, and TNF- α ELISA (enzyme linked immunosorbent assay) kits based on the method of Kola-Mustapha et al. [13]. EIA kit (Cayman Chemical, Ann Arbor, MI, USA) was used to study the inhibitory activity of the samples against Human Recombinant COX-2 according to the manufacturer's instructions. Reaction buffer solution (960 μ L) containing 0.1 M Tris-HCL, 5 mM EDTA, and 2 mM phenol; COX-2 enzymes (10 μ L) in the presence of heme (10 μ L) with 10 μ L of the prepared sample solutions was added to the wells. The solutions were incubated for 10 min at 37 °C. Then, 10 μ L of the extract solution was added, and then the COX reaction was stopped by adding 50 μ L of 1 M HCL. The plate was washed to remove any unbound reagents and Ellman's reagent was added to the well. The distinct yellow color obtained as a result of the enzymatic reaction was determined spectrophotometrically using a microtiter plate reader at a wavelength of 412 nm. The % inhibition was obtained by comparison with the absorbance gotten from the blank/negative control. The procedure was repeated using TNF- α and PGE-2 ELISA respectively and the % inhibition of COX-2, TNF- α and PGE by each prepared sample was calculated.

Formulation of emulgels incorporated with extract

Preparation of emulgels

The methods of Khullar and co-workers [14] and Panwar and co-workers [15] were modified in the preparation of the herbal emulgels. The gel base was prepared by dispersing carbopol 940 in purified water with constant stirring at a moderate speed using mechanical mixer, then the pH adjusted to 6 - 6.5 using tri-ethanol amine (TEA). The oil phase of the emulsion was prepared by adding Span 20 to light liquid paraffin while the aqueous phase was prepared by dispersing Tween 20 in purified water. These surfactants (Span 20 and Tween 20) were used at formulation concentrations of 1.0 % w/w and 0.5 % w/w respectively. Methyl and ethyl paraben were dissolved in propylene glycol and the plant extract (drug) was dissolved in ethanol. The three (3) mixtures: propylene glycol with the preservatives, extract in ethanol and the purified water containing the tween were poured into a beaker and stirred to form the aqueous phase needed for the formulation of the emulsion. Both the oily and aqueous phases were separately heated to 70–80 °C; then the oily phase added to the aqueous phase with continuous stirring until it cooled to room temperature to form an emulsion. The gel and emulsion were mixed at a ratio of 1:1 (gel: emulsion). Glutaraldehyde was added during the mixing of gel and emulsion at a

Table 1

Composition of emulgels from ethanol extract of *Arctium lappa* root.

Ingredients	Emulgels (% ^w / _w)			
	F1	F2	F3	F4
<i>A. lappa</i> extract	0.00	0.50	1.00	1.5
Carbopol 940	1.00	1.00	1.00	1.00
Liquid paraffin	7.50	7.50	7.50	7.50
Span 20	1.00	1.00	1.00	1.00
Tween 20	0.50	0.50	0.50	0.50
Propylene glycol	5.00	5.00	5.00	5.00
Ethanol	2.50	2.50	2.50	2.50
Ethyl paraben	0.01	0.01	0.01	0.01
Methyl paraben	0.03	0.03	0.03	0.03
Glutaraldehyde	0.50	0.50	0.50	0.50
Clove oil	–	–	–	10.00
Mentha oil	–	6.00	–	–
Purified water	q.s	q.s	q.s	q.s

concentration of 0.5 % w/w.

Different emulgels were formulated with varied quantities of penetration enhancers and gelling agent. Emulgels were formulated as depicted in Table 1 with different concentrations of the extract. Emulsion was prepared similarly, across the formulations. They were stored in ointment jars ready for analysis.

Post formulation evaluation of emulgels

Physical evaluation

Evaluation of organoleptic properties which included appearance, texture, colour and odour were carried out for the formulated emulgel. In addition, ease of application and removal of emulgel; and feel of emulgel on the skin were conducted.

Drug-vehicle compatibility

The emulgel formulated was examined for breakage and separating out of the extract from the base to define whether the emulgel base used were physically compatible with the extract combination.

Spreading coefficient

The slip and drag properties of emulgels were used to measure the spreading coefficient parameter. For this, 2 g of emulgel was placed on a ground glass slide affixed on a wooden block. Followed by a 500 mg weight positioned on two slides sandwiched with the emulgel for a duration of five (5) minutes. A known weight on a pan was attached to the pulley via a hook. The required duration in seconds, to cross 5 cm was recorded. A better spreading coefficient was indicated by a shorter interval.

$$S = \frac{M \times L}{T}$$

Here, S, spreadability (gcm/s); M, mass (g); L, length (cm); T, time (s).

Centrifuge test

Emulgel stability was investigated against gravity by Centrifuge 5430 (Eppendorf, US). Each emulgel was centrifuged separately for 5, 15, 30, and 60 min at 2000 rpm. Finally, each emulgel was checked in terms of sedimentation.

pH measurement

A pH meter (Hanna, England) was used to determine the pH of the emulgels. The probe of the pH meter was dipped in each of the undiluted emulgel preparations at room temperature. pH readings were taken after stabilization of display. Each test was conducted in triplicates and the results computed.

Viscosity measurement

Viscosity measurements of emulgels pre-conditioned for 30 min at 25 °C (room temperature) were evaluated by the NDJ-5S Digital Display Viscometer (Rinch, China). Measurements were conducted in three replicates and noted.

Anti-inflammatory activities of herbal emulgels

The anti-inflammatory activity of the emulgel formed was studied using Enzyme-Linked Immunosorbent Assay by measuring its inhibitory activity on in-vitro reactions involving COX-2, TNF- α , and PGE. Graded concentrations (0, 0.5, 1.0, and 1.5 % w/w) of emulgel were prepared by dissolving the emulgels in dimethyl sulfoxide (DMSO) with agitation until complete dissolution was achieved. A positive control solution was prepared by dissolving diclofenac gel (1 % w/w) in methanol. PGE-2 Human Elisa Kit, COX-2 EIA kit (Cayman Chemical, Ann Arbor, MI, USA), and TNF- α EIA kit were used to measure the % inhibition of PGE-2, COX-2, and TNF- α respectively by the emulgels and controls following the manufacturers' instructions. A target-specific antibody had been pre-coated in the wells of the supplied microplate to which the target chemokine, the prepared sample and reaction buffer were added. The different mediators (COX-2, TNF- α , and PGE) used were the human recombinant kinds of the mediators which were commercially available and procured for this study. The solutions were incubated at 37 °C for 10 min after which the reaction was stopped by adding HCL, the plates were washed, the reagent to precipitate the colorimetrically assayed reaction was added and absorbance was taken spectrophotometrically at 412 nm, using the negative control in which the solvent (DMSO) was used as sample as blank and % Inhibition was calculated and computed. The percentage of inhibition was related to diclofenac emulgel (standard drug), at a concentration of 1 % w/w to determine their anti-inflammatory activities [13].

Statistical analysis

The results recorded were written as mean $\pm$ SD (standard deviation). ANOVA (One-way analysis of variance) was utilized as basis for statistical comparison. Differences between the percentage inhibition of the inflammatory mediators by the herbal emulgels and the standard (control) were analysed. Graph Pad Prism (version 7.0) software was deployed for statistical analysis. The *p* values were set at lower than 0.05 to reflect significant differences between the tested samples.

Results

Characterization of extract

Appearance and pH

The percentage yield of methanol root extract of *A. lappa* obtained was 22 % w/w. Extract was dark-brown and sticky in appearance, with a pH of 6.3.

Phytochemical screening

Phytochemical (preliminary) analysis of *A. lappa* methanol root extract *A. lappa* showed that terpenoids, saponins, phenolics, tannins, steroids, alkaloids, anthocyanins, and flavonoids were present. Quantitative estimation of *Arctium lappa* methanol root extract is shown in Table 2.

Extract's anti-inflammatory activity

Extract produced concentration dependent inhibition of COX-2, PGE₂, and TNF- α as shown in Table 3.

Evaluation of emulgels

Evaluation of physical characteristics

Herbal emulgels were homogenous preparations from *Arctium lappa* root extracts with glossy appearance, cream or brown colour, woody odour, and easy to apply and remove as presented in Table 4.

Drug-vehicle compatibility

The emulgels formulated were examined for breakage and separating out of the extract away from the base. This defined whether the emulgel base used was physically compatible with the extract combination as presented in Table 5.

Centrifuge test

The compatibility of the extract with the vehicle was determined using a centrifuge test method in which no sedimentation or separation was detected as presented in Table 5. This depicts the vehicle as compatible with the extract and all other ingredients. The spreading coefficients, pH, and viscosity of the emulgels were also shown in Table 5.

Herbal emulgels' anti-inflammatory activities

Herbal emulgels showed significant inhibition of PGE-2, TNF- α , and COX-2 activities as shown in Table 6.

Discussion

The increased interest in medicinal plants' applications for healthcare needs call for holistic research in the use of natural products for the management of various ailments [16]. *Arctium lappa* is being used in traditional settings for the treatment of ailments which include rashes, boils, sore throat, and several skin complications [2]. Inflammation arises as a defense mechanism or response to host cell invasion by foreign substance which could be of the microbial type. It is usually a protective response that is localized. It encompasses a series of events which occur due to the actions of different physiological mediators. They include exudation of fluids such as plasma proteins, dilatation of venules, arterioles, and capillaries with amplified vascular permeability, and migration of leukocyte into the inflammatory region. [17,18]. In this study, as presented in Table 3, *A. lappa* showed significant ($p < 0.05$) in-vitro anti-inflammatory activity. When compared with the effect produced by diclofenac (at 1 % w/w), the 80 mg/mL concentration of the extract inhibited TNF-alpha and PGE-2 inflammatory mediators better than the positive control. Similarly, according to Table 6, the herbal emulgel of *A. lappa* produced significant anti-inflammatory action evidenced in its inhibition of COX-2, TNF-alpha and PGE-2

Table 2
Quantitative estimation of the different phytochemicals contained in *Arctium lappa* methanol root extract.

Phytochemical	Quantity (mg/g)
Terpenoids	12.44 $\pm$ 0.04
Saponins	27.47 $\pm$ 0.24
Phenolics	2.97 $\pm$ 0.02
Tannins	3.47 $\pm$ 0.03
Steroids	121.27 $\pm$ 0.75
Alkaloids	11.85 $\pm$ 0.07
Coumarins	0.00 $\pm$ 0.00
Anthocyanins	0.40 $\pm$ 0.00
Flavonoids	129.03 $\pm$ 0.26

Presentation of data: Mean $\pm$ SD ($n = 3$).

Table 3In-vitro inhibitory activities of *Arctium lappa* root extract on the different mediators of inflammation (COX-2, PGE₂, and TNF-α).

Mediator	% Inhibition				
	20 mg/mL	40 mg/mL	60 mg/mL	80 mg/mL	Diclofenac (1% w/w)
COX-2	32.90 ± 1.24 ^b	43.40 ± 1.54 ^b	54.90 ± 2.32 ^b	68.40 ± 2.17 ^b	85.50 ± 3.86 ^a
TNF-α	14.77 ± 0.96 ^b	36.77 ± 1.35 ^b	60.10 ± 3.50 ^b	87.10 ± 4.24 ^b	52.33 ± 2.32 ^a
PGE ₂	25.73 ± 1.04 ^b	43.90 ± 2.86 ^b	58.90 ± 2.72 ^a	66.57 ± 2.36 ^a	61.73 ± 2.74 ^a

Presentation of data: mean ± SD (n = 3).

^a p < 0.05.^b p < 0.01 versus vehicle treated control. Two-way ANOVA was conducted and multiple comparison Tukey post hoc tests.**Table 4**

Evaluation of physical characteristics of herbal emulgels.

Emulgel	Appearance	Odour	Colour	Ease of applying	Ease of removing	Homogeneity
F1	Glossy	Woody	White	Easy	Easy	Homogenous
F2	Glossy	Woody	Cream	Easy	Easy	Homogenous
F3	Slightly Glossy	Woody	Light Brown	Easy	Easy	Homogenous
F4	Least glossy	Woody	Light Brown	Easy	Easy	Homogenous

Table 5

Results of centrifuge test, spreading coefficient, drug-vehicle compatibility, pH and viscosity of formulated herbal emulgels.

Emulgel	Drug-vehicle compatibility	Centrifuge test	Spreading coefficient (g cm/s)	pH	Viscosity (Pas)
F1	Compatible	–	20.5 ± 0.78	4.97 ± 0.04	3.36 ± 0.40
F2	Compatible	–	18.35 ± 0.45	5.15 ± 0.03	3.52 ± 0.20
F3	Compatible	–	17.50 ± 0.82	5.26 ± 0.04	3.78 ± 0.30
F4	Compatible	–	15.25 ± 0.90	5.42 ± 0.05	3.95 ± 0.50

Legend for centrifuge test: +, sediment; –, no sediment. Presentation of data: Mean ± SD (n = 3).

Table 6Herbal emulgels' in vitro inhibitory activities on the different mediators of inflammation (COX-2, PGE₂, and TNF-α).

Mediators	F1	F2	F3	F4	Diclofenac emulgel (1 % w/w)
COX-2	29.39 ± 8.67 ^b	31.22 ± 7.30 ^b	30.69 ± 6.53 ^b	35.63 ± 6.23 ^b	57.75 ± 13.28 ^a
TNF-α	27.55 ± 5.26 ^b	39.25 ± 12.87 ^b	30.73 ± 4.97 ^b	60.73 ± 8.30 ^b	89.01 ± 10.39 ^a
PGE	7.66 ± 4.49 ^b	8.70 ± 2.67 ^b	24.79 ± 2.12 ^b	33.19 ± 6.72 ^a	29.11 ± 1.26 ^a

Presentation of data: Mean ± SD (n = 3).

^a p < 0.05.^b p < 0.01 versus vehicle treated control. Two-way ANOVA was conducted and multiple comparison Tukey post hoc tests.

activities. Immune responses to injury and infection that are controlled include molecular signaling networks which are complex; giving actions that are coordinated and frequently opposing. The major bioactive lipid network is basically eicosanoid and is one of the greatly complex and challenging pathways which makes it difficult in a physiological framework, to map. Inflammasome formation and cytokine signaling are likened to eicosanoid signaling, which are mainly pro-inflammatory constituent of immune responses that are innate [19]. In the present study, formulation 'F3' which contains 0.5 % w/w of *Arctium lappa* root extract showed the highest inhibitory activity on PGE₂ while F4 (1 % w/w *Arctium lappa* root extract) displayed the highest inhibitory activity on TNF-α.

The usage of gels had been on an increase because conventional preparations of semi solid types which include creams and ointments, with problems such as stickiness, being prone to rancidity, lesser dissolution and spreading coefficient. In addition, these conventional preparations are also commonly prone to phase inversion. However, gels are commonly limited to the delivery of drugs of hydrophobic nature. Interestingly, poorly water-soluble drugs have been effectively delivered using the emulsion-based gel (emulgel) delivery strategy [20]. As shown in Table 5, centrifuge test showed no sedimentation in the emulgel. Better spreading coefficient was also achieved at shorter intervals. These outcomes can be associated with the results of viscosity presented for the emulgel in Table 5. This range of viscosity that produced desirable sedimentation and spreadability properties in the emulgel can be utilized as a guide for the consistency of future emulgel formulations. The herbal emulgels were easily spreadable and removable without difficulty. However, F1 (0 % w/w) did not spread as easily as any of the other formulations including F4 (1 % w/w) which had the highest spreadability profile. This could be attributed to the absence of a penetration enhancer and the extract in F1 (0 % w/w) [15]. In addition, the herbal emulgel was found to be rich in known metabolites with anti-inflammatory actions including flavonoids, phenolics, tannins and saponins as corroborated by earlier researchers [21–23].

The pH of the formulated emulgels were found to be slightly as shown in Table 5. It is preferred that creams, gels, ointments, and

other preparations for application to the skin have slightly acidic pH as the pH of the skin surface as proven by past potentiometric measurements is 4.5–5.5 on an average. Based on the results of compatibility expressed in Table 5, an absence of separation after formulation suggests that the herbal extract utilized in this study (*A. lappa*) is stable in the materials with which the emulgel base was formulated.

The outcome of this study reveals the possibilities of the emulgels incorporated with *A. lappa* methanol root extract to act against mediators encountered in pain and inflammation. This further consolidates our earlier research works on potential topical herbals in pain and inflammation management [13,24].

Conclusion

The emulgels formulated exhibited inhibitory activities against the tested inflammatory mediators PGE, TNF- α and COX-2. Formulations F2, F3 and F4 had significant inhibitory activities compared with the standard diclofenac emulgel 1 % w/w. The results obtained for the herbal emulgel formulations confirm that the roots of *Arctium lappa* possess promising in-vitro anti-inflammatory and COX-2 inhibitory activities and thus, holds good potentials in the topical therapeutic treatment of pain and inflammation associated with the management of rheumatic pain.

This research approach is novel, as this is the first time the root extract of *Arctium lappa* will be formulated into an emulgel intended for topical application in the management of inflammation. It is a realistic advancement to currently existing therapies in inflammation management because of the ‘green’ origin of the active pharmaceutical ingredient and the topical model of administration adopted through an emulgel base. It is impactful and immediately relevant to the African community because the therapeutic agent at the center of the formulation is widely available and affordable on the African continent. So technically, the researchers have attempted in this study to use what we have (a plant), to get what we want (an effective alternative to synthetic medications) in the management of inflammatory conditions. From a broader perspective, improving the management of inflammation which is associated with numerous diseases will ultimately reduce morbidity on the African continent and contribute to the maintenance of good health in citizens.

The African Union’s first goal on the ‘Agenda 2063’ is to provide “A High Standard of Living, Quality of life and Wellbeing for all its citizens”. At a global prevalence of 20–25 %, Chronic inflammatory skin disorders significantly affect the quality of life for citizens [25]. This is worsened in Africa where more than half of the population lack access to essential medicines [26]. In light of this, the World Health Organization recommends traditional medicine as a way to increase access to healthcare via medical treatments already available in our natural flora [26]. *Arctium lappa* can be found and grown in many regions across Africa, hence providing an available source of phytotherapy. This study adds to the increasing knowledge base of plants and therapeutic activity, one which may help in the development of a traditional medicines compendium for Africans by Africans, informing health policies and practices in the region. Additionally, our study is relevant towards the achievement of the third Sustainable Development Goal (SDG 3), specifically on targets 3.4 (Non-communicable diseases) and 3.8 (Universal health coverage). By advancing the use of herbal emulgels in skin disorders, this study can help in reducing the prevalence of non-communicable inflammatory skin disorders, providing access to healthcare for all.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

All data generated or analyzed during this study are included in this published article.

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CRediT authorship contribution statement

Adeola Tawakalitu Kola-Mustapha: Conceptualization, Supervision, Formal analysis, Writing – original draft, Writing – review & editing. **Muhammed Olawale Abdulrahman:** Methodology, Writing – original draft, Writing – review & editing. **Ismail O. Ishola:** Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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