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PHARMACODYNAMIC EVALUATION OF USHNAVAAYUMENICHOORANAM IN A CARRAGEENAN-INDUCED PAW EDEMA MODEL IN WISTAR RATS

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ABSTRACT

Background: Phytochemicals derived from medicinal plants continue to play a vital role in the development of anti-inflammatory drugs. UshnaVaayuMeniChooranam (UVMC), a traditional Siddha polyherbal formulation, is commonly used for the treatment of inflammatory disorders. However, there is limited scientific evidence supporting its anti-inflammatory efficacy. The present study aimed to evaluate the in vivo anti-inflammatory activity of UVMC in Wistar rats using the carrageenan-induced paw edema model.

Materials and Methods: Acute inflammation was induced by a subplantar injection of 1% carrageenan. The animals were divided into four groups (n = 6): disease control, indomethacin (10 mg/kg), UVMC (200 mg/kg), and UVMC (400 mg/kg). The percentage inhibition of paw edema was calculated. Histopathological examination of paw tissues and analysis of hematological parameters were also performed.

Results: UVMC produced a significant and dose-dependent reduction in paw edema compared to the disease control group ($P < 0.05$–0.001). At the fifth hour, the percentage inhibition was 25.18% (200 mg/kg) and 40.62% (400 mg/kg), which was comparable to indomethacin (36.74%). Histopathological findings revealed reduced inflammatory cell infiltration and restoration of normal tissue architecture, particularly in the high-dose group.

Conclusion: The findings demonstrate that UVMC possesses significant anti-inflammatory activity in an acute experimental model, thereby supporting its traditional use in Siddha medicine.

Keywords: *UshnaVaayuMeniChooranam, anti-inflammatory activity, in vivo study, carrageenan-induced paw edema, Siddha medicine.*

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INTRODUCTION

Medicinal plant-derived phytochemicals have been historically valuable sources of therapeutic compounds and are still essential to the discovery of new drugs [1]. Plant-based medications are still readily available and reasonably priced for primary healthcare in many developing countries. Herbal remedies are widely used to treat a variety of human and livestock ailments due to their diverse biological activities, cultural acceptance, and relatively fewer side effects. Their use as complementary or alternative therapies is steadily growing worldwide [1]. The body executes inflammation as a defensive biological reaction to fend off infections, injuries, toxic substances, and other damaging stimuli. Heat, redness, pain, swelling, and compromised tissue function are its distinctive characteristics [2]. Inflammation's main goal is to trigger cellular defense systems that get rid of dangerous substances and encourage tissue healing. The release of inflammatory mediators controls the initiation, progression, and resolution of this reaction [3]. Reactive oxygen and nitrogen species (ROS and RNS), pro-inflammatory cytokines like TNF-α and interleukins, and enzymes like cyclooxygenase-1 and cyclooxygenase-2 (COX-1 and COX-2) are all produced in greater amounts by host cells during inflammation. These substances are important

mediators and biomarkers of the inflammatory process [4]. The mechanism by which nonsteroidal anti-inflammatory medications (NSAIDs) perform is by suppressing COX enzymes and preventing the production of prostaglandins. NSAIDs' long-term safety is limited, nonetheless, by the frequent gastrointestinal and renal side effects linked to chronic usage [3]. As a result, medicinal plants with anti-inflammatory qualities and maybe better safety profiles are becoming more and more popular.

The World Health Organization states that traditional medicine serves primary healthcare to a significant proportion of the world's population [5]. Numerous plant-derived bioactive substances, especially polyphenols, have been found through ethnobotanical and pharmacological research to be able to modulate inflammatory pathways, including inflammasome activation linked to metabolic and chronic diseases [5]. The significance of medicinal plants in current pharmacological research is further supported by the fact that the abundant reservoir of plant secondary metabolites continues to provide a basis for the creation novel anti-inflammatory drugs.

A traditional Siddha polyherbal preparation, *UshnaVaayu Meni Chooranam* (UVMC) is used to treat ailments including *UshnaVaayu*(Flatulence / Indigestion), *Mandai Noi* (Diseases of head), *Peenisam*(Diseases of nose), *and Pavuthiram*(Fistula-in-ano) [6]. The principal ingredients of UVMC include *Acalyphaindica* and *Cuminumcyminum*, both of which have been reported to possess significant anti-inflammatory properties [7,8]. There is limited scientific data assessing the formulation's overall anti-inflammatory potential, despite the known pharmacological actions of its constituent parts. Therefore, utilizing an experimental model of acute inflammation, the current work was conducted to examine UVMC's in-vivo anti-inflammatory effectiveness.

MATERIALS AND METHODS

Chemicals and Reagents

Carrageenan (λ-carrageenan), indomethacin, and carboxymethyl cellulose (CMC) were procured from standard commercial suppliers. Every reagent that was utilized was analytical grade. On the day of the experiment, new suspensions and solutions were made.

Test Formulation

The preparation of UVMC followed accepted pharmacopeial practices. In order to achieve consistent dosing for the experimental administration, the formulation was suspended in 1% CMC and given orally using a gastric gavage needle.

Experimental Animals

The study employed healthy adult Wistar albino rats (180–220 g) of either sex. The animals were kept in controlled settings with a 12-hour light/dark cycle, a temperature of 24 ± 1°C, a relative humidity of 55 ± 15%, and unrestricted access to water and a normal laboratory pellet diet.

The experimental protocol was carried out in accordance with CPCSEA rules and ARRIVE recommendations for reporting animal research, and it was examined and approved by the Institutional Animal Ethics Committee (IAEC Approval No: AKCP/IAEC/17/2024-2025).

Experimental Design and Randomization

Using a simple random allocation technique, the animals were divided into four groups (n = 6 per group). To reduce observational bias, researchers who measured paw volume and evaluated histopathology were blinded to treatment allocation.

- Group I served as the disease control (vehicle + carrageenan).
- Group II received UVMC at 200 mg/kg (p.o.).
- Group III received UVMC at 400 mg/kg (p.o.).
- Group IV received indomethacin (10 mg/kg, p.o.) as the reference standard.

The dose selection was based on preliminary tolerability assessment and traditional therapeutic equivalence scaling.

Induction of Acute Inflammation

Acute inflammation was induced using the carrageenan-induced paw edema model, a validated model for screening anti-inflammatory agents that reflects biphasic mediator release. One hour after oral administration of the test drug or standard, 0.1 mL of 1% carrageenan solution was injected into the subplantar region of the right hind paw.The early phase (0–2 h) represents histamine and serotonin-mediated events, while the late phase (3–5 h) is primarily mediated by prostaglandins and other inflammatory cytokines. [9]

Assessment of Paw Edema

A digital plethysmometer was used to measure the volume of the paws before the carrageenan injection (baseline) and one, two, three, four, and five hours after the induction. The following formula was used to determine the percentage inhibition of edema, which represented the anti-inflammatory effect:

Inhibition of paw edema (%) = (Oc - Ot) / Oc × 100

WhereOc represents the mean paw volume of the disease control group and Ot represents the mean paw volume of the treated groups [9].

Hematological Evaluation

Blood samples were obtained by retro-orbital puncture under light anesthesia at the conclusion of the trial period. An automated hematologyanalyzer was used to examine hematological parameters such as the platelet count, total leukocyte count (WBC), hemoglobin (Hb), hematocrit (HCT), red blood cell count (RBC), and differential leukocyte count.

Histopathological Analysis

Paw tissues were collected and preserved in 10% neutral buffered formalin after the animals were euthanized humanely. Hematoxylin and eosin (H&E) was used to stain 4-5 µm slices after dehydration and paraffin embedding. A veterinary pathologist who was board-certified conducted the histological assessment.

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A semi-quantitative scoring method (0–5 scale) was used to rate the degree of inflammation based on the percentage of tissue involvement.

Statistical Analysis

Mean ± SEM (n = 6) was used to express the data. One-way analysis of variance (ANOVA) and Dunnett's multiple comparison test were used in the statistical study to compare the treated and disease control groups. At $P < 0.05$, statistical significance was taken into account. GraphPad Prism software (Version 5.0) was used to conduct statistical and graphical analyses. [9]

RESULTS

Effect of UVMC on Carrageenan-Induced Paw Edema Volume:

The disease control group experienced a progressive and time-dependent rise in paw volume following subplantar injection of 1% carrageenan, indicating that acute inflammation had been successfully induced. At the fifth hour after induction, the amount of paw edema peaked at 1.90 ± 0.01 mL (Table 1; Figure 1).At all observed time intervalsoral UVMC pre-treatment led to a dose-dependent reduction in paw edema. In comparison to the disease control group, the low-dose group (200 mg/kg) showed a moderate decrease in paw volume. The reduction was more noticeable in the high-dose group (400 mg/kg), especially in the late stage of inflammation (3–5 hours). Indomethacin (10 mg/kg), the usual medication, also considerably decreased paw edema at every time point (Table 1).

Table 1: Effect of *U.V.M. Chooranam* on carrageenan induced paw edema in rat.

Groups	I st hour	2nd hour	3rd hour	4th hour	5th hour
GROUP I (Carrageenan)	1.76± 0.01	1.80± 0.01	1.83± 0.02	1.87± 0.02	1.90± 0.01
GROUP 2 LOW	1.69± 0.02	1.60± 0.01	1.68± 0.01	1.47± 0.01	1.44± 0.01
GROUP 3 HIGH	1.52± 0.02	1.42± 0.01	1.48± 0.01	1.38± 0.03	1.22± 0.01
GROUP 4 (Indomethacin (10mg/kg/bw)	1.57± 0.007	1.43± 0.01	1.54± 0.007	1.47± 0.01	1.31± 0.01

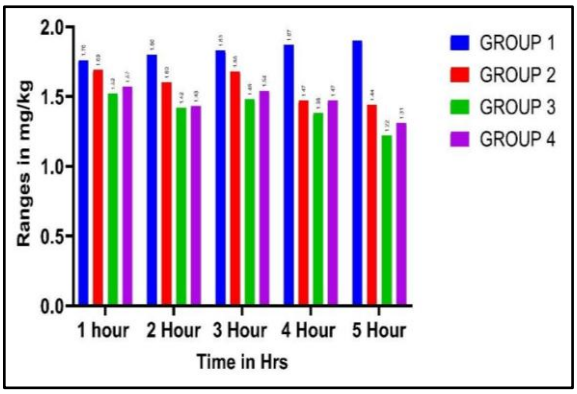

Figure 1: Effect of U.V.M.C on carrageenan induced paw edema in rat

Percentage Inhibition of Carrageenan-Induced Edema:

Table 2 and Figure 2 show the percentage inhibition of paw edema in comparison to disease control. UVMC clearly showed that inflammation was inhibited in a dose-dependent manner. In contrast to the 36.74% shown with indomethacin, the percentage inhibition at the fifth hour was 25.18% in the UVMC 200 mg/kg group and 40.62% in the UVMC 400 mg/kg group. Interestingly, at subsequent time points, the high-dose UVMC group showed more inhibition than the usual medication (Table 2). Significant differences between the treatment groups and the disease control were found by statistical analysis ($P < 0.05–0.001$). Sustained anti-inflammatory activity is indicated by the percentage inhibition gradually increasing over time.

Table 2: Percentage Inhibition of paw edema in U.V.M.C and Carrageenan treated rats:

Groups	1st Hour	2nd Hour	3rd Hour	4th Hour	5th Hour
Normal (Carragenan)	-	-	-	-	-
Low Dose (UVMCLow.)	4.86	11.42	14.78	20.64	25.18
High Dose (UVMC High.)	14.92	23.36	26.84	33.48	40.62
Indomethacin (10 mg/kg b.w.)	11.28	21.96	24.32	29.84	36.74

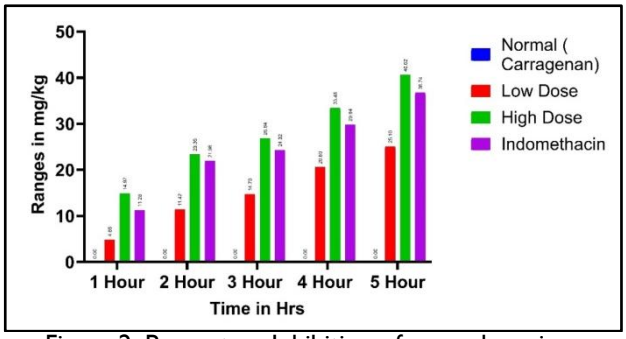

Figure 2: Percentage Inhibition of paw edema in U.V.M.C and Carrageenan treated rats

Effect of UVMC on Inflammation-Associated Hematological Parameters:

Systemic inflammatory activation was demonstrated by the significant increase in total leukocyte count (12.34 ± 0.48 $\times 10^9$/L) and granulocyte and eosinophil fractions that followed carrageenan-induced inflammation (Table 3).

These hematological changes were considerably altered by UVMC treatment. The total leukocyte count in the high-dose group decreased to 8.62 ± 0.58 $\times 10^1$/L, which was comparable to the indomethacin group's values of 9.82 ± 0.36 $\times 10^1$/L. When comparing UVMC-treated animals to disease control, differential leukocyte analysis revealed lower granulocyte and eosinophil/basophil/monocyte counts (Table 3). Furthermore, when compared to untreated inflammatory animals, the UVMC-treated groups showed improved hematocrit levels, hemoglobin concentration, and red blood cell count. Compared to disease control, UVMC groups had higher platelet counts, which may indicate that the inflammatory and vascular responses had stabilized.

Table 3: Effects of UVMC on Hematological parameters of rats induced with inflammation using Carragenan:

Parameters	Untreated control	UVMC Low	UVMC High	Indomethacin
RBC ($\times 10^{12}$/L)	5.92 ± 0.31	6.98 ± 0.36	7.54 ± 0.29	6.02 ± 0.28
Haemocrit (%)	37.46 ± 1.85	42.08 ± 1.44	45.36 ± 1.27	39.12 ± 1.62
Haemoglobin (g/dL)	12.08 ± 0.63	13.96 ± 0.74	14.82 ± 0.51	12.64 ± 0.58
Platelet ($\times 10^9$/L)	326.80 ± 61.34	548.20 ± 43.18	634.60 ± 39.72	348.60 ± 57.92
WBC ($\times 10^9$/L)	12.34 ± 0.48	9.18 ± 0.42	8.62 ± 0.58	9.82 ± 0.36
Lymphocyte ($\times 10^9$/L)	9.06 ± 0.66	7.28 ± 0.46	6.92 ± 0.51	7.86 ± 0.54
Granulocyte ($\times 10^9$/L)	0.68 ± 0.09	0.64 ± 0.08	0.46 ± 0.06	0.88 ± 0.12
Eosinophill,Basophill,Mongocyte ($\times 10^9$/L)	2.60 ± 0.21	0.92 ± 0.14	0.78 ± 0.11	1.08 ± 0.19

Histopathological Evaluation of Paw Tissue

Paw sections from the disease control group showed significant chronic granulomatous diffuse inflammation, with interstitial edema and considerable inflammatory cell infiltration, according to histopathological analysis (Figure 3A). With less cellular infiltration and edema, the UVMC 200 mg/kg group exhibited mild inflammatory variations (Figure 3B). The UVMC 400 mg/kg group showed almost complete restoration of normal tissue architecture together with minimal inflammatory changes (Figure 3C). The indomethacin-treated group's paw sections showed no discernible inflammatory pathology and appeared within normal histological bounds (Figure 3D). In the carrageenan-induced acute inflammation model, these histomorphological results support the plethysmometric and hematological data, demonstrating UVMC's dose-dependent anti-inflammatory effectiveness.

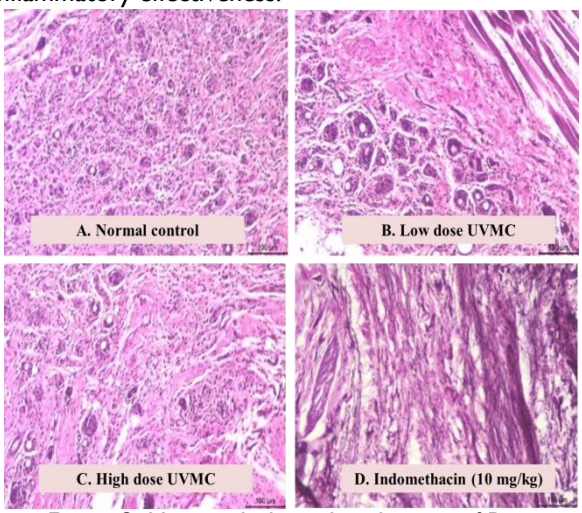

Figure 3: Histopathological evaluation of Paw Tissue in Carrageenan – Induced Inflammation (H& Staining, 40x)

DISCUSSION

The carrageenan-induced paw edema model, a validated experimental model for screening anti-inflammatory drugs, was used in this investigation to examine the anti-inflammatory potential of UshnaVaayuMeniChooranam (UVMC) [10]. This model has a biphasic response and closely resembles acute inflammatory processes. Histamine, serotonin, and bradykinin are released during the initial phase (0–2 h), while prostaglandins, nitric oxide, and pro-inflammatory cytokines including TNF-α and IL-1β are mostly responsible for the late phase (3–6 h) [11,12]. As a result, substances that considerably reduce edema caused by carrageenan are thought to be able to modify important inflammatory mediators.

At 200 and 400 mg/kg, UVMC significantly and dose-dependently inhibited paw edema in the current investigation. The higher dosage was as effective as the common cyclooxygenase (COX) inhibitor indomethacin. Given that prostaglandins play a major role in the later phases of carrageenan inflammation,

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the observed decrease in edema supports the possibility that UVMC inhibits COX-2 activity, which could disrupt prostaglandin production [13]. This suggests that arachidonic acid metabolism, a key mechanism in inflammatory signaling, may be modulated by the formulation.

The anti-inflammatory activity was structurally confirmed by histopathological investigation (Figure 3). Prominent leukocyte infiltration, interstitial edema, and disruption of normal dermal architecture-all hallmarks of an acute inflammatory response-were observed in the disease control group [14]. On the other hand, those treated with UVMC demonstrated a significant decrease in the infiltration of inflammatory cells and the preservation of tissue integrity, especially at 400 mg/kg. This implies prevention of neutrophil migration and decrease of vascular permeability, two crucial processes in acute inflammation.

The main components of UVMC, *Acalyphaindica*and *Cuminumcyminum*, which are both recognized for their anti-inflammatory and antioxidant qualities, may be responsible for its anti-inflammatory action [7, 8]. By inhibiting NF-κB activation and lowering pro-inflammatory mediators including COX-2, iNOS, and TNF-α, their phytoconstituents like flavonoids, phenolics, and terpenoidsmodify inflammatory pathways [15, 16]. This mechanism could explain the observed decrease in inflammatory cell infiltration and edema. Because activated leukocytes produce reactive oxygen species (ROS) that increase cytokine production and prolong injury, oxidative stress is a major factor in inflammatory tissue damage [17]. The antioxidant properties of plant-derived polyphenols scavenge reactive oxygen species (ROS) and enhance endogenous defenses. Accordingly, the reduction of oxidative stress-induced inflammatory cascades may also be a mechanism by which UVMC has an anti-inflammatory impact.

Polyherbal formulations frequently show multi-target activities with potentially better safety profiles than synthetic NSAIDs like indomethacin, which predominantly target COX enzymes but are linked to gastrointestinal and renal side effects with extended usage [13]. Pharmacological plausibility is supported by the observed dose-dependent response, which also points to synergistic interactions between the formulation's phytoconstituents. Through the simultaneous regulation of several inflammatory pathways, herbal medications can work in concert to increase therapeutic efficacy [18].

Despite all factors considered, the results show that UVMC significantly reduces inflammation in an acute experimental paradigm, which is corroborated by both structural (histopathological) and functional (paw edema inhibition) data. In order to fully comprehend its mode of action and translational potential, more research involving chronic inflammation models, molecular biomarker analysis (COX-2, TNF-α, IL-6), and mechanistic pathway studies is necessary, though, as the current study concentrated on an acute inflammatory model.

CONCLUSION

In the carrageenan-induced paw edema model, the current study shows that *Ushna Vaayu Meni Chooranam*(UVMC) has strong anti-inflammatory properties. Histopathological data showing better tissue architecture and less inflammatory alterations corroborated the formulation's dose-dependent reduction in paw swelling.

These results offer initial experimental support for the conventional application of UVMC in inflammatory diseases. The findings imply that the formulation has promising pharmacological potential and could be the starting point for additional research into molecular causes, models of chronic inflammation, and clinical assessment to determine its therapeutic usefulness.

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CONFLICT OF INTEREST

None

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ETHICAL APPROVAL

Approved by IAEC (Approval number: AKCP/IAEC/17/2025-2026), Arulmigu Kalasalingam College of Pharmacy, Chennai.

ABBREVIATION

UVMC -.*Ushna Vaayu Meni Chooranam*

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