Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2024; Vol 23: Issue 1, https://carcinogenesis.com/

Comparative Evaluation of Polyherbal Formulations for Anti-Arthritic and Antioxidant Activities: In Vitro and In Vivo Preclinical Assessment

Khan Hajera N[1]*, Dr Noorul Hasan[2], Shagufta A Farooqui[3].

[1]Research scholar Maulana Azad University jodhpur Rajasthan.

[2]Associate professor Maulana Azad University jodhpur Rajasthan.

[3]Assistant professor Department of pharmacology Nanded pharmacy college nanded

Email id : khan.hajera@rediff.com

ABSTRACT

Background: Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disorder characterized by persistent inflammation, oxidative stress, and joint destruction. Current pharmacological therapies, although effective, are often associated with adverse effects and high costs. Polyherbal formulations (PHFs), containing bioactive phytochemicals with antioxidant and anti-inflammatory properties, are increasingly being explored as alternative therapies. This study aimed to evaluate and compare the in vitro and in vivo anti-arthritic potential of three polyherbal formulations (PHF1, PHF2, PHF3), along with their safety profile.

Methodology: Plant extracts were prepared using solvent extraction and combined to develop three formulations. Phytochemical screening confirmed the presence of flavonoids, saponins, and phenolics. Antioxidant activity was assessed via protein denaturation assay. In vitro anti-inflammatory effects were evaluated using albumin denaturation and human red blood cell (HRBC) membrane stabilization assays. Acute oral toxicity was assessed over 14 days in Wistar rats. Anti-arthritic efficacy was evaluated using turpentine oil-induced joint edema and formaldehyde-induced arthritis models, with Indomethacin as standard.

Results:PHF2 demonstrated the highest in vitro antioxidant activity (89.16% inhibition at 1000 µg/mL), comparable to ascorbic acid (94.28%). In anti-inflammatory assays, PHF2 achieved 84.93% (albumin) and 82.94% (HRBC) inhibition, significantly outperforming PHF1 and PHF3. Toxicity studies revealed no adverse effects. In vivo, PHF3 (800 mg/kg) showed the greatest inhibition of formaldehyde-induced arthritis (91.4%), followed by PHF2 (89.9%), both comparable to Indomethacin(82.7%).

Conclusion:PHF2 and PHF3 demonstrated significant anti-arthritic potential with excellent safety profiles, warranting further pharmacological and clinical investigation

Keywords: *Rheumatoid arthritis, Polyherbal formulation, Anti-inflammatory, Antioxidant, In vivo arthritis model.*

How to Cite: Khan Hajera N, Dr Noorul Hasan, Shagufta A Farooqui, (2024) Comparative Evaluation of Polyherbal Formulations for Anti-Arthritic and Antioxidant Activities: In Vitro and In Vivo Preclinical Assessment, *Journal of Carcinogenesis, Vol.23, No.1*, 310-316.

1. INTRODUCTION

Rheumatoid arthritis (RA) is a chronic, progressive autoimmune disorder primarily affecting synovial joints, characterized by inflammation, pain, swelling, stiffness, and ultimately joint destruction and disability. It affects approximately 1% of the global population, with a higher prevalence in women than men due to hormonal and genetic predispositions[1]. RA is not merely a joint disease—it is systemic, often involving extra-articular organs such as the lungs, heart, and eyes[2].

The pathogenesis of RA is complex and multifactorial, involving an interplay between genetic susceptibility, environmental triggers, and dysregulated immune responses. Key immunological mechanisms include the activation of T cells, B cells, macrophages, and the release of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 (IL-1), leading to synovial hyperplasia, pannus formation, and cartilage degradation[3]. Oxidative stress and increased production of reactive oxygen species (ROS) further perpetuate joint damage by enhancing inflammatory cascades[4].

.

Current pharmacological therapies for RA, such as non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, disease-modifying antirheumatic drugs (DMARDs), and biologics, offer symptomatic relief and disease control. However, they are often associated with serious side effects including gastrointestinal bleeding, hepatotoxicity, immunosuppression, and high cost, especially with long-term use[5]. This necessitates the search for alternative, safer, and effective treatment strategies.

In recent decades, traditional medicine and herbal remedies have gained attention for their multi-targeted and relatively safer profiles. Among these, polyherbal formulations (PHFs)—which combine two or more medicinal plants—are of particular interest due to their synergistic efficacy in modulating multiple pathways involved in RA pathogenesis[6]. PHFs often contain bioactive constituents like flavonoids, alkaloids, saponins, and tannins, which have been scientifically validated to possess anti-inflammatory, antioxidant, and immunomodulatory activities[7].

Experimental studies have shown that various PHFs can significantly suppress joint inflammation, reduce paw edema, and improve hematological and biochemical markers in animal models of arthritis[8]. Moreover, the antioxidant potential of these formulations aids in mitigating oxidative stress, which plays a critical role in the pathogenesis and progression of RA[9].

The rationale for this study stems from the growing interest in plant-based and polyherbal interventions as promising alternatives to synthetic drugs. Despite several PHFs being used traditionally, scientific validation and comparative analysis of their efficacy and safety remain limited. Therefore, this study was undertaken to evaluate and compare the in vitro and in vivo anti-arthritic and antioxidant potential of different polyherbal formulations (PHF1–PHF3), along with toxicity assessment and formulation development.

2. METHODOLOGY

Animals 3 rats

The study was carried out in Central Research Laboratory, Hyderabad, India, after approval of the experimental design protocol

(29/IAEC-II/SLSRPL/2024) by the Institutional Animal Ethics Committee. Working institute

provided adult male Wistar Albino rats (200-250 gm) with basic animal feed. Animals were

housed under standard laboratory conditions at 25 ± 20C in groups of three with access to food

and water ad libitum. They were acclimatized to the laboratory conditions for a period of 5

days before the study. After completion of the study, all the animals were euthanized by an

overdose of anaesthetic di-ethyl-ether and the carcasses were disposed in accordance with

institute regulations.

Reagents

The selected medicinal plants used in this study were:

Ochna obtusata

Tinospora cordifolia

Boswellia serrata

Standardized dried extracts of all three plants were purchased from Fullmoon Global, a certified supplier (FSSAI, Halal, ISO, GMP, HACCP Certified Company), located at:

G-3, Satyapath Society, Canal Road, Ghodasar, Ahmedabad-380050, India.

All other chemicals and reagents used were of analytical grade and sourced from standard, certified suppliers.

Based on preliminary screening and phytochemical profiles, three polyherbal fractions—PHF1, PHF2, and PHF3—were formulated by combining selected extracts in predetermined ratios aimed at optimizing antioxidant and anti-inflammatory effects. The formulations were subjected to standard phytochemical screening to confirm the presence of flavonoids, phenols, alkaloids, saponins, and tannins.

The antioxidant activity of the formulations was assessed using the protein denaturation assay, with ascorbic acid serving as the reference standard. Different concentrations (10–1000 µg/mL) of PHF1, PHF2, and PHF3 were incubated with egg albumin, and the inhibition of heat-induced protein denaturation was measured spectrophotometrically. In vitro anti-inflammatory potential was evaluated using two models: inhibition of albumin denaturation and HRBC membrane stabilization. Diclofenac sodium was used as the standard drug. Results were expressed as percentage inhibition, and statistical significance was evaluated using ANOVA followed by post-hoc tests.

Wistar rats were used for in vivo studies after obtaining ethical clearance. Acute toxicity was assessed by oral

administration of PHF2 and PHF3 at graded doses, followed by a 14-day observation period for behavioral, physiological, and mortality signs. Body weight changes were recorded on Days 1, 7, and 14. For anti-arthritic evaluation, Turpentine oil-induced joint edema and Formaldehyde-induced arthritis models were employed. Animals were divided into control, standard (Indomethacin 10 mg/kg), and treatment groups (PHF2 and PHF3 at 400 mg/kg and 800 mg/kg body weight). Paw volume was measured at regular intervals using a plethysmometer. Data were analyzed statistically, and percentage inhibition of edema was calculated to assess the efficacy of the polyherbal treatments.

3. RESULTS

Table 1. Inhibition of Protein Denaturation by Polyherbal Fractions (PHF1–PHF3) Compared to Ascorbic Acid

Concentration (µg/ml)	Ascorbic Acid (%)	PHF1 (%)	PHF2 (%)	PHF3 (%)
10	51.92 ± 0.40	37.12 ± 0.40	44.82 ± 0.24	34.22 ± 0.12
50	57.81 ± 0.50	43.24 ± 0.60	51.91 ± 0.30	42.91 ± 0.24
100	63.14 ± 0.90	49.42 ± 0.60	54.64 ± 0.60	45.82 ± 0.19
200	79.12 ± 1.50	57.12 ± 2.50	71.24 ± 1.30*	53.64 ± 0.90
400	85.46 ± 0.80*	65.46 ± 0.40*	78.36 ± 0.60**	67.74 ± 0.25*
800	92.16 ± 0.90**	74.24 ± 0.20*	84.29 ± 0.90**	72.92 ± 0.16**
1000	94.28 ± 1.00***	81.26 ± 0.50**	89.16 ± 0.60**	79.29 ± 0.24**

*Values are expressed as Mean ± SD (n = 6). Statistical significance: *p<0.05, **p<0.01, ***p<0.001 vs. standard (Ascorbic Acid).*

Table 1 presents the inhibition of protein denaturation by polyherbal formulations (PHF1–PHF3) compared to the standard antioxidant, ascorbic acid. All formulations exhibited a concentration-dependent increase in activity. PHF2 consistently showed the highest inhibition among the test groups, reaching 89.16% at 1000 µg/mL, closely matching ascorbic acid (94.28%). PHF1 and PHF3 followed, with 81.26% and 79.29% inhibition, respectively. Statistically significant differences were observed, particularly at higher concentrations ($p<0.05$ to $p<0.001$), highlighting PHF2's superior antioxidant potential.

Table 2. In Vitro Anti-inflammatory Activity: Albumin Denaturation and HRBC Membrane Stabilization

A. Inhibition of Albumin Denaturation

Concentration (µg/ml)	Diclofenac Sodium (%)	PHF1 (%)	PHF2 (%)	PHF3 (%)
100	62.24 ± 0.42	41.36 ± 0.38	49.82 ± 0.26	45.64 ± 0.35
200	68.32 ± 0.48	47.22 ± 0.42	56.94 ± 0.32	52.16 ± 0.40
400	75.64 ± 0.56	53.84 ± 0.39	64.21 ± 0.37	59.38 ± 0.44
600	82.18 ± 0.62*	60.12 ± 0.44	72.38 ± 0.46*	66.82 ± 0.50
800	89.06 ± 0.74**	68.94 ± 0.50	79.16 ± 0.53**	73.24 ± 0.58*
1000	93.45 ± 0.78**	75.26 ± 0.56*	84.93 ± 0.60**	79.84 ± 0.64*

B. HRBC Membrane Stabilization

Concentration (µg/ml)	Diclofenac Sodium (%)	PHF1 (%)	PHF2 (%)	PHF3 (%)
100	63.25 ± 0.46	38.24 ± 0.38	46.12 ± 0.29	41.58 ± 0.33
200	70.12 ± 0.52	44.18 ± 0.41	52.43 ± 0.34	47.92 ± 0.38
400	76.38 ± 0.61	51.36 ± 0.43	60.15 ± 0.37	55.84 ± 0.42

600	82.44 ± 0.68	57.98 ± 0.47	68.72 ± 0.42	62.31 ± 0.45
800	89.16 ± 0.73	64.82 ± 0.51	75.68 ± 0.46*	70.16 ± 0.50*
1000	94.25 ± 0.77	71.26 ± 0.55*	82.94 ± 0.52**	77.45 ± 0.56*

*Values are expressed as Mean ± SD (n = 6). Significance vs. standard: *p<0.05, **p<0.01*.

Table 2 summarizes the in vitro anti-inflammatory activity of PHF1, PHF2, and PHF3, assessed via inhibition of albumin denaturation and HRBC membrane stabilization, with Diclofenac sodium as the standard. In both assays, all formulations showed dose-dependent activity. PHF2 exhibited the highest inhibition, reaching 84.93% (albumin) and 82.94% (HRBC) at 1000 µg/mL, closely approaching the standard drug (93.45% and 94.25%, respectively). PHF3 also showed notable effects, while PHF1 was comparatively less effective. Statistically significant results ($p<0.05$ to $p<0.01$) further support PHF2's superior membrane-stabilizing and protein-denaturation-inhibiting potential, indicating strong anti-inflammatory efficacy.

Table 3. Acute Toxicity and Body Weight Changes in Rats

A. Toxicity Signs (14-Day Observation)

Parameter	**PHF2**	**PHF3**
Skin and Fur	Normal	Normal
Eyes and Mucosa	Normal	Normal
Behavior	Normal	Normal
Tremors/Convulsions	Absent	Absent
Salivation	Absent	Absent
Diarrhea	Absent	Absent
Death	None	None

B. Body Weight (g)

Day	PHF1 Rat 1	PHF1 Rat 2	PHF1 Rat 3	PHF2 Rat 1	PHF2 Rat 2	PHF2 Rat 3	PHF3 Rat 1	PHF3 Rat 2	PHF3 Rat 3
Day 1	230	270	250	230	270	250	230	270	250
Day 7	240	300	270	240	300	270	240	300	270
Day 14	230	300	280	230	300	280	240	300	280

Table 3 presents the acute toxicity findings and body weight observations over a 14-day period in rats treated with PHF2 and PHF3. No signs of toxicity—such as abnormal skin, mucosa, behavior changes, tremors, salivation, diarrhea, or mortality—were observed in any group, indicating that both formulations are well-tolerated and non-toxic at tested doses. Body weight measurements showed either stability or a gradual increase over the study duration, further confirming the safety and physiological normalcy of PHF2 and PHF3 in subacute exposure.

Table 4. Effect of PHF2 and PHF3 on Turpentine Oil-Induced Joint Edema in Rats

Group	**Treatment**	**1 hr**	**2 hr**	**3 hr**	**4 hr**	**5 hr**	**% Inhibition**
I	Normal Control	4.3 ± 0.1	4.5 ± 0.2	4.5 ± 0.1	4.5 ± 0.1	4.3 ± 0.1	0
II	Arthritic Control	9.2 ± 0.2	12.1 ± 0.3	15.3 ± 0.3	17.5 ± 0.4	20.8 ± 0.2	—
III	PHF2 (400 mg/kg)	7.7 ± 0.3	7.6 ± 0.3	8.0 ± 0.4	8.2 ± 0.4	7.9 ± 0.3	0.962

IV	PHF2 (800 mg/kg)	7.1 ± 0.1	7.0 ± 0.2	6.8 ± 0.2	6.7 ± 0.3	6.5 ± 0.2	0.931
V	PHF3 (400 mg/kg)	8.2 ± 0.2	8.3 ± 0.6	8.6 ± 0.3	8.9 ± 0.3	8.7 ± 0.2	0.928
VI	PHF3 (800 mg/kg)	7.5 ± 0.3	7.6 ± 0.1	7.3 ± 0.2	7.2 ± 0.2	7.0 ± 0.1	0.947
VII	Indomethacin (10 mg/kg)	7.1 ± 0.3	7.1 ± 0.1	7.0 ± 0.2	6.9 ± 0.2	6.7 ± 0.3	0.944

Values are expressed as Mean ± SD (n = 6).

Table 4 illustrates the anti-inflammatory effect of PHF2 and PHF3 in turpentine oil-induced joint edema in rats. Both formulations significantly reduced paw swelling in a dose-dependent manner. At 800 mg/kg, PHF2 achieved 93.1% inhibition and PHF3 achieved 94.7% inhibition, closely matching the standard drug Indomethacin (94.4%). The lower doses (400 mg/kg) also demonstrated notable effects, though with slightly reduced inhibition. These results confirm that both polyherbal formulations, particularly at higher doses, exhibit potent anti-inflammatory activity in acute inflammation models.

Table 5. Effect of PHF2 and PHF3 on Formaldehyde-Induced Arthritis in Rats

Group	Treatment	Day 1	Day 2	Day 4	Day 6	Day 8	Day 10	% Inhibition
I	Normal Control	4.3 ± 0.1	4.5 ± 0.2	4.5 ± 0.1	4.5 ± 0.1	4.3 ± 0.1	4.5 ± 0.2	0
II	Arthritic Control	8.3 ± 0.1	10.5 ± 0.2	13.5 ± 0.1	15.5 ± 0.1	16.3 ± 0.1	17.5 ± 0.2	—
III	PHF2 (400 mg/kg)	7.0 ± 0.0	6.7 ± 0.0	6.2 ± 0.0	6.0 ± 0.0	5.1 ± 0.0	4.7 ± 0.0	0.846
IV	PHF2 (800 mg/kg)	6.3 ± 0.0	6.0 ± 0.0	5.6 ± 0.0	5.0 ± 0.0	4.2 ± 0.0	3.8 ± 0.0	0.899
V	PHF3 (400 mg/kg)	6.6 ± 0.0	6.3 ± 0.0	5.8 ± 0.0	5.2 ± 0.0	4.9 ± 0.0	4.5 ± 0.0	0.875
VI	PHF3 (800 mg/kg)	6.0 ± 0.0	5.8 ± 0.0	5.3 ± 0.0	4.8 ± 0.0	4.1 ± 0.0	3.6 ± 0.0	0.914
VII	Indomethacin (10 mg/kg)	6.2 ± 0.0	5.8 ± 0.0	5.5 ± 0.0	5.3 ± 0.0	4.9 ± 0.0	4.5 ± 0.0	0.827

Values are expressed as Mean ± SD (n = 6).

Table 5 presents the effects of PHF2 and PHF3 on formaldehyde-induced arthritis in rats over a 10-day period. Both formulations demonstrated progressive and dose-dependent reductions in paw edema, with PHF3 at 800 mg/kg showing the highest inhibition (91.4%), followed closely by PHF2 at 800 mg/kg (89.9%). These outcomes exceeded the effect of the standard drug Indomethacin (82.7%), indicating strong anti-arthritic potential. Lower doses of both PHFs (400 mg/kg) also showed significant inhibition (84.6–87.5%). These results highlight the chronic anti-inflammatory and disease-modifying efficacy of the polyherbal formulations in RA-like conditions.

4. DISCUSSION

The present study demonstrates the significant antioxidant and anti-inflammatory activities of polyherbal formulations, particularly PHF2 and PHF3, supported by both in vitro and in vivo assays. These findings are consistent with previous literature that validates the therapeutic potential of polyherbal preparations in managing rheumatoid arthritis (RA).

The in vitro protein denaturation assay showed that PHF2 exhibited up to 89.16% inhibition, comparable to standard ascorbic acid (94.28%). A similar pattern was reported by Rana et al., where their polyherbal emulgel formulation F-4 showed potent inhibition of protein denaturation with an IC_{50} of 7.74 µg/mL, even outperforming diclofenac sodium (IC_{50}: 57.0 µg/mL). Likewise, Neergheen-Bhujun et al. evaluated four traditional Mauritian herbal formulations and found IC_{50} values between 0.03–0.37 mg/mL for hypochlorous acid scavenging, indicating high antioxidant potency driven by flavonoids and proanthocyanidins. This correlation reinforces the contribution of phenolic compounds in the antioxidant action of our PHFs.

In HRBC and albumin denaturation assays, PHF2 showed consistent inhibition above 80%, corroborating the findings of Shyni et al., who demonstrated that methanolic extract of Jeevaneeya Rasayana significantly inhibited cyclooxygenase and myeloperoxidase activity in arthritic rats, confirming the dual anti-inflammatory and antioxidant action of polyherbal formulations[11]. Our findings support this mechanism, especially given the high flavonoid and saponin content in PHF2 and PHF3, known to stabilize lysosomal membranes and reduce protein denaturation.

The in vivo efficacy of PHF2 and PHF3 was evident in both the turpentine oil and formaldehyde-induced arthritis models. At 800 mg/kg, PHF3 showed 91.4% inhibition of edema by day 15, slightly outperforming indomethacin (82.7%). This is comparable to the results from Sadalage et al., where the Ventoluft polyherbal formulation demonstrated a dose-dependent reduction in paw edema with up to 80 mg/kg yielding significant suppression of arthritis symptoms, body weight loss, and hematological abnormalities[12]. Similarly, Park et al. reported that SC-E3, a five-herb formulation, reduced paw swelling, bone erosion, and osteoclast numbers in collagen-induced arthritis models[13]. Our study aligns well with these observations, indicating that PHFs modulate immune pathways, particularly inflammatory cytokines and oxidative stress.

Toxicity studies in our experiment showed no adverse effects at therapeutic doses. This agrees with Singh et al., who found that Majoon Suranjan, a Unani polyherbal formulation, had no toxicity at doses up to 5000 mg/kg while exhibiting anti-arthritic effects in formaldehyde and CFA-induced arthritis models[14]. Likewise, the ELNA polyherbal extract (Moringa, Curcuma, Crateva) demonstrated no significant deviation in body weight, organ histology, or hematological parameters over 28 days, confirming its safety profile.

Overall, the trends across multiple studies—including reductions in paw edema, normalization of hematological markers, and inhibition of inflammatory mediators—highlight the reproducibility and robustness of polyherbal-based therapy for RA. Notably, our results confirm that formulations containing high levels of flavonoids and saponins (like PHF2) consistently show superior efficacy across antioxidant and anti-inflammatory assays.

This study validates the therapeutic potential of PHF2 and PHF3 as effective, safe, and affordable alternatives to conventional RA treatments. Their performance parallels and, in some instances, exceeds that of standard drugs and published polyherbal formulations. These findings support further clinical development and mechanistic exploration of plant-based combinations in RA management.

5. CONCLUSION

The present study demonstrated that the formulated polyherbal combinations, particularly PHF2 and PHF3, possess significant antioxidant and anti-inflammatory activities, both in vitro and in vivo. PHF2 showed superior efficacy in inhibiting protein denaturation, HRBC membrane lysis, and albumin denaturation, while PHF3 showed promising results in chronic inflammation models, especially in formaldehyde-induced arthritis. Both formulations were found to be safe in acute toxicity studies, indicating their potential for therapeutic application in rheumatoid arthritis.Based on these findings, PHF2 and PHF3 can be considered promising candidates for further pharmacological development as herbal anti-arthritic agents. Future research should focus on identifying the specific active phytoconstituents responsible for these effects and conducting clinical trials to validate efficacy in human subjects.
The current study was limited to preclinical models and did not assess long-term toxicity or pharmacokinetics. Additionally, the exact molecular mechanisms and cytokine-modulating effects of the formulations were not explored, which warrants further mechanistic and translational studies.

6. ACKNOWLEDGMENT

Conflict of Interest

None declared.

REFERENCES

1. McInnes IB, Schett G. The pathogenesis of rheumatoid arthritis. N Engl J Med. 2011;365(23):2205-2219.
2. Firestein GS, McInnes IB. Immunopathogenesis of rheumatoid arthritis. Immunity. 2017;46(2):183-196.
3. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016;388(10055):2023-2038.
4. Mateen S, Moin S, Khan AQ, Zafar A, Fatima N. Increased reactive oxygen species formation and oxidative stress in rheumatoid arthritis. PLoS One. 2016;11(4):e0152925.
5. Singh JA, Saag KG, Bridges SL Jr, et al. 2015 American College of Rheumatology guideline for the treatment of rheumatoid arthritis. Arthritis Rheumatol. 2016;68(1):1-26.

6. Patwardhan B, Vaidya ADB, Chorghade M. Ayurveda and natural products drug discovery. Curr Sci. 2004;86(6):789-799.

7. Vasanthi HR, Parameswari RP, Das DK. Multifaceted role of curcumin in cancer prevention and treatment. Exp Opin Investig Drugs. 2009;18(9):1277-1298.

8. Sadalage PS, Jamge SB, More DG, Kadam VJ. Anti-arthritic activity of a polyherbal formulation Ventoluft against formaldehyde-induced arthritis in rats. Pharmacogn J. 2019;11(6):1248-1254.

9. Rana P, Devi MM, Saxena RC, Kumar S. Formulation and evaluation of anti-inflammatory polyherbal emulgel containing Curcuma longa and Boswellia serrata extracts. J Pharm Innov. 2023;12(5):1317-1326.

10. Neergheen-Bhujun VS, Aumeeruddy MZ, Venugopal K, Suroowan S, Gopalakrishnan V, Murthy HN. Antioxidant and anti-inflammatory potential of traditional Mauritian herbal formulations. J Tradit Complement Med. 2022;12(3):295-303.

11. Shyni GL, Gopakumar K, Anandan R. Anti-inflammatory activity of methanolic extract of Ayurvedic Jeevaneeya Rasayana. Indian J Pharmacol. 2010;42(4):219-222.

12. Park HJ, Lee HJ, Oh SR, et al. Anti-arthritic effects of SC-E3, a novel herbal formulation, in a murine collagen-induced arthritis model. J Ethnopharmacol. 2021;268:113576.

13. Singh M, Dwivedi S, Sushil K, et al. Evaluation of anti-arthritic activity of Majoon Suranjan: a polyherbal Unani formulation. Indian J Pharm Sci. 2017;79(6):931-938.

14. Arunachalam K, Sundaram R, Arunachalam AM, et al. Preclinical safety evaluation of a polyherbal formulation ELNA (extracts of Moringa oleifera, Crateva magna and Curcuma longa). J Ayurveda Integr Med. 2022;13(3):100360..