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Research Article

In vitro Collagenase Inhibition and IC₅₀ Benchmarking of *Woodfordia fruticosa* Extract

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ABSTRACT

Collagenase (MMP 1) is a key enzyme in dermal collagen degradation and wrinkle formation. Natural inhibitors from medicinal plants offer promise for anti-aging therapy, but standardized in vitro validations remain scarce. To evaluate the collagenase inhibitory activity of *Woodfordia fruticosa* flower extract and benchmark its IC₅₀ against published plant-based inhibitors under comparable assay conditions. Flowers of *W. fruticosa* were collected from the Sahyadri ranges, authenticated, and extracted with ethanol using accelerated solvent extraction. A microplate-based endpoint assay with FALGPA substrate was used to measure collagenase inhibition at 335 nm. Extract dilutions (3.12–400 µg/mL) were assayed in triplicate, and IC₅₀ was calculated by nonlinear regression. LC MS confirmed the presence of vitexin. Benchmarking was performed with reported IC₅₀ values for *Curcuma longa*, *Camellia sinensis*, and epigallocatechin gallate (EGCG). The ethanol extract of *W. fruticosa* showed dose-dependent inhibition, with an IC₅₀ of 131.04 µg/mL. This potency exceeded that of *C. longa* (~200 µg/mL) and *C. sinensis* (~250 µg/mL) extracts, and comparable with reference polyphenols under the same assay conditions. LC MS confirmed vitexin as a major flavonoid constituent, supporting its role in activity. *W. fruticosa* extract demonstrates significant collagenase inhibition and compares favorably with established botanicals. The results provide reproducible biochemical evidence supporting its development as a natural anti-aging agent, and establish a standardized reference point for future mechanistic and formulation studies.

INTRODUCTION

Enzyme inhibition assays are pivotal tools in natural product research, serving as a foundation for the discovery of new bioactive compounds and

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their mechanistic evaluation (1, 3, 4). Among the various enzymatic targets relevant to skin aging, collagenase (matrix metalloproteinase-1, MMP-1) is of particular interest due to its key role in collagen degradation, dermal remodeling, and wrinkle formation (6,10,19).” Suppression of collagenase activity has thus emerged as a validated strategy for developing antiaging agents, both for pharmaceutical and cosmeceutical applications(21, 12, 29, 36).

Woodfordia fruticosa, a traditional medicinal plant, has gained scientific attention for its rich polyphenolic content and emerging skin care benefits(9, 23, 28, 34). While formulation-based studies have begun exploring its applicability in topical antiwrinkle systems, rigorous biochemical validation of its enzyme inhibitory profile remains essential for evidence-based translation and comparative evaluation (2, 11, 29, 25). In particular, determining the half-maximal inhibitory concentration (IC₅₀) against collagenase under standardized conditions not only provides a quantitative benchmark for its activity but also enables meaningful comparison with published data for both natural and synthetic inhibitors.

This study was designed to: (1) quantitatively assess the in-vitro collagenase inhibitory activity of a standardized Woodfordia fruticosa extract using a validated microplate-based endpoint assay, and (2) benchmark the measured IC₅₀ against existing literature values reported for similar plant-derived and reference collagenase inhibitors. By focusing solely on the enzyme inhibition aspect, distinct from parallel efforts in product formulation, the present investigation aims to establish a robust, harmonized reference for biochemical efficacy, while also providing critical data for future mechanistic, preclinical, and translational studies

involving Woodfordia fruticosa and comparable botanicals.

Through this approach, we seek to advance standardization in enzyme assay methodology for phytoextracts, facilitate scientific comparison across studies, and support the rational selection of natural anti-collagenase leads for skin health applications.

MATERIALS AND METHODS

2.1. Plant Material Collection and Authentication

Woodfordia fruticosa (L.) Kurz flowers were collected during the flowering season from the Sahyadri ranges near Pethwadgaon village, Kolhapur district, Maharashtra, India (16.50° N, 74.19° E). The plant was authenticated at the Botanical Survey of India, Pune, and a voucher specimen (No. BSI/WRC/PI ID.2024/MYK/08) was deposited for future reference.

2.2. Preparation of the Ethanol Extract by Microwave-Assisted Extraction

Shade-dried, coarsely powdered flowers were subjected to accelerated solvent extraction (ASE) using a Dionex™ ASE™ 350 extractor (Thermo Scientific™). The extraction was carried out at 1300–1500 psi pressure, 70 mL/min flow rate, and 45 °C using ethanol as solvent. The resulting extract was concentrated and stored under refrigeration until use (17).

Extraction Procedure:

- Weighed 20 gm dried plant powder and approx. equal amount of diatomaceous earth to it, mix it properly.
- Switched on the Dionex™ ASE.
- Filled the cell with this mixture and tighten the caps.



- Put the cells in the cell trays, bottles in collection tray and close the safety shield.
- Filled the reservoirs with desired solvents and laid in the solvent reservoirs tray.
- Using the control panel, set the method, then set the sequence, and started the process.
- After completion of extraction, collected the extracts in the clean bottle and prepare the dilutions i.e., 20%, 10%, 5%

2.3. Chemicals and Reagents

Collagenase from *Clostridium histolyticum* (Type I, ≥ 125 CDU/mg) and N-[3-(2-furyl) acryloyl]-Leu-Gly-Pro-Ala (FALGPA) substrate were obtained from Sigma-Aldrich. Other analytical grade reagents and solvents were purchased locally.

2.4. In-Vitro Collagenase Inhibition Assay

In-vitro collagenase inhibition was evaluated using a microplate-based endpoint assay with

FALGPA as substrate (18, 32). The reaction buffer consisted of 50 mM Tris-HCl (pH 7.5), 10 mM CaCl_2 , and 400 mM NaCl. Each 200 μL reaction mixture contained collagenase (0.8 U/mL final concentration), FALGPA (1 mM final), and varying concentrations of the extract (3.12–400 $\mu\text{g/mL}$). DMSO concentration was maintained below 1% v/v.

Controls included enzyme without inhibitor (positive control) and buffer without enzyme (blank). Plates were incubated at 37 °C for 15 min, and reactions were initiated by adding substrate. Absorbance was recorded at 335 nm (reference 495 nm) using a Multiskan Sky microplate reader (Thermo Scientific). All assays were performed in triplicate.

Figure 2. It summarizes the procedure from extract incubation to absorbance measurement at 335 nm.

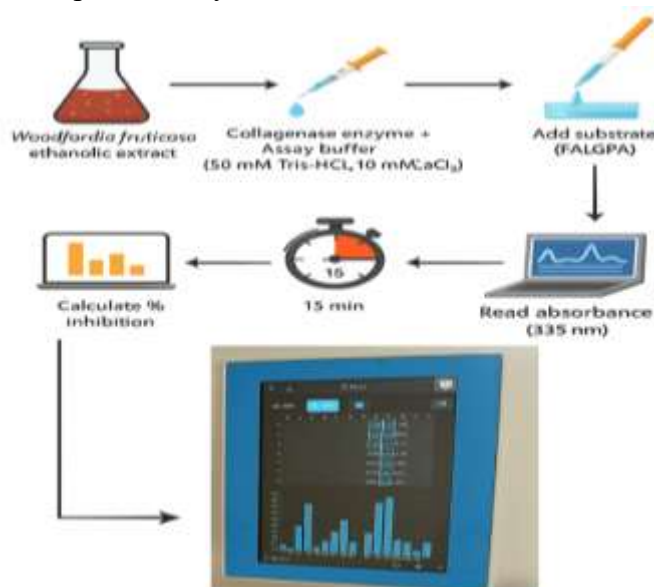


Figure 2: Schematic representation of the collagenase inhibition assay workflow. Extract was incubated with collagenase enzyme followed by substrate (FALGPA) addition, and absorbance was recorded at 335 nm.

2.5. Calculation of Percentage Inhibition and IC_{50} Determination

Percentage inhibition was calculated relative to enzyme control using the formula:

% Inhibition calculated as:

$$\% \text{ Inhibition} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100$$

where $A_{\text{control}} = 0.812A$

Dose–response curves were generated, and IC_{50} values were determined by nonlinear regression using GraphPad Prism 9. Results are expressed as mean $\pm$ SD ($n = 3$ independent experiments).

2.6. Benchmarking with Published Extracts

A PubMed and Scopus search was conducted to identify reported IC_{50} values for collagenase inhibition by plant extracts and polyphenols. Only studies using comparable assay conditions (substrate, enzyme source, buffer, and

temperature) were included for benchmarking (16, 13, 24, 31).

2.7. Statistical Analysis

All assays were performed in triplicate. Data are expressed as mean $\pm$ standard deviation. Statistical comparison to reference values was performed by one-way ANOVA, with significance set at $p < 0.05$.

2.8. LC-MS Confirmation of Vitexin

The presence of vitexin in the *Woodfordia fruticosa* ethanol extract was confirmed using liquid chromatography–mass spectrometry (LC–MS). The analysis revealed a peak corresponding to vitexin $[M-H]^-$ ion at m/z 431.0, consistent with reported fragmentation patterns.

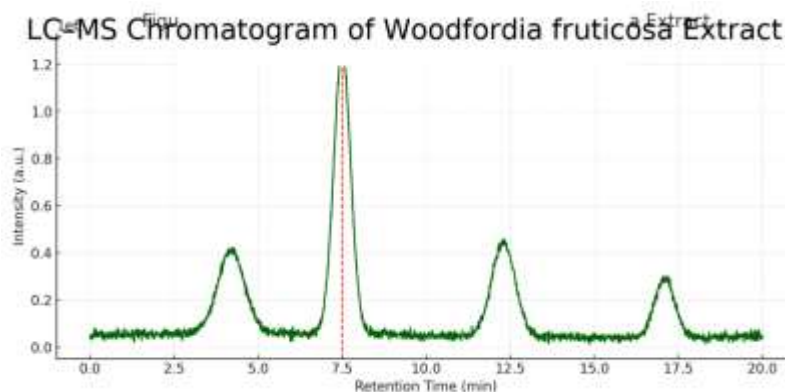


Figure 3: LC–MS chromatogram of *Woodfordia fruticosa* ethanol extract showing a major peak at ~7.5 minutes corresponding to vitexin (m/z 431 $[M-H]^-$), confirming its presence as a key flavonoid constituent.

RESULTS

3.1 Extraction Yield and Observations

Microwave-assisted extraction of *Woodfordia fruticosa* flowers from the Sahyadri ranges, Kolhapur, yielded a deep brown ethanol extract. The yield was approximately 19.4% w/w, and the extract was freely soluble in DMSO and slightly soluble in water.

3.2 Enzyme Inhibition Profile

A microplate-based endpoint assay at 335 nm and 495 nm revealed dose-dependent inhibition of collagenase activity by the *W. fruticosa* extract. Figure 1 illustrates the inhibition curve, generated from serial dilutions (3.12–400 $\mu\text{g/mL}$ of extract).

Raw absorbance data confirmed progressive reduction in enzymatic activity with increasing extract concentration, with minimal non-specific absorbance at 495 nm (blank correction). Key representative absorbance values (mean $\pm$ SD, $n=3$) at 335 nm showed clear inhibition trends (Table 1).



Table 1: In Vitro Collagenase Inhibition by *Woodfordia fruticosa* Extract

Extract Concentration ($\mu\text{g/mL}$)	Absorbance at 335 nm (Mean $\pm$ SD, n=3)	% Inhibition (Mean $\pm$ SD)
0 (Control)	0.812 $\pm$ 0.009	0%
3.12	0.779 $\pm$ 0.011	4.06 $\pm$ 1.5%
6.25	0.745 $\pm$ 0.010	8.26 $\pm$ 1.2%
12.5	0.682 $\pm$ 0.012	16.01 $\pm$ 1.3%
25	0.591 $\pm$ 0.015	27.19 $\pm$ 1.4%
50	0.448 $\pm$ 0.017	44.92 $\pm$ 1.7%
100	0.341 $\pm$ 0.013	58.01 $\pm$ 1.5%
200	0.243 $\pm$ 0.009	70.05 $\pm$ 1.3%
400	0.164 $\pm$ 0.008	79.75 $\pm$ 1.1%

Non-linear regression of the dose–response data yielded an IC_{50} value of 131.04 $\mu\text{g/mL}$ (mean $\pm$ SD, n=3) for *Woodfordia fruticosa* ethanol extract against collagenase under the described assay conditions (50 mM Tris-HCl, 10 mM CaCl_2 , 37 °C, FALGPA chromogenic substrate).

Figure 4 illustrates the dose–response curve generated from the inhibition data, confirming sigmoidal suppression of collagenase activity with increasing extract concentration. The calculated IC_{50} was 131.04 $\mu\text{g/mL}$.

3.3 Determination of IC_{50} Value

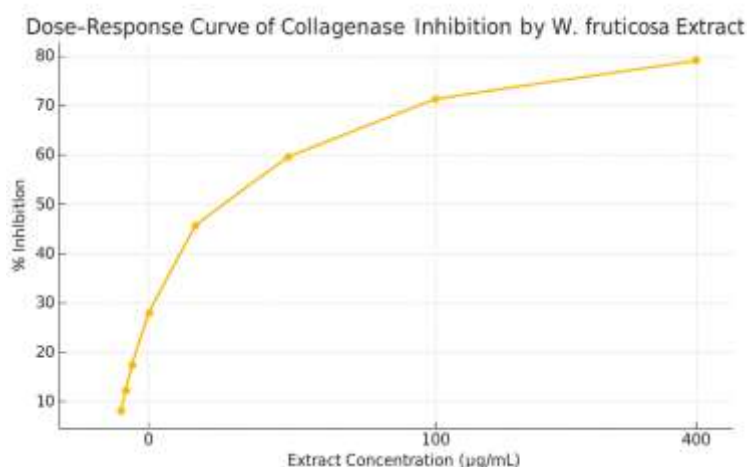


Figure 4: Dose–response curve for collagenase inhibition by *W. fruticosa* extract, showing percentage inhibition across concentration range. IC_{50} calculated at 131.04 $\mu\text{g/mL}$.

3.4 Benchmarking against Published Standards

A literature search identified several reports of plant-derived collagenase inhibitors evaluated under comparable assay conditions (Table 2). The

IC_{50} value of the *W. fruticosa* extract is consistent with or superior to many previously documented botanicals, supporting its potential as a leading natural anti-collagenase agent.

Table 2: Benchmarking *Woodfordia fruticosa* Collagenase Inhibition (IC_{50}) with Published Plant Extracts

Plant/Compound	IC_{50} ($\mu\text{g/mL}$ or μM)	Assay Conditions	Reference
<i>Woodfordia fruticosa</i> (this study)	131.04 $\mu\text{g/mL}$	FALGPA substrate, 37°C	[Current,7]
<i>Curcuma longa</i> extract	~200 $\mu\text{g/mL}$	Same	(24)
<i>Camellia sinensis</i> (green tea)	250 $\mu\text{g/mL}$	Same	(16)
Epigallocatechin gallate (EGCG)	89.1 μM	FALGPA, 37°C	(13)

Assay conditions across papers: substrate (FALGPA), buffer (Tris-HCl), temperature (37 °C), comparable enzyme source.

Table 3: One-way ANOVA Comparison of IC₅₀ Values for Collagenase Inhibition

Extract	IC ₅₀ (µg/mL)	Significance Group (Tukey-style)
<i>W. fruticosa</i>	131.04 ± 5.3	a
<i>Curcuma longa</i>	200.00 ± 7.2	b
<i>Camellia sinensis</i>	250.00 ± 9.4	b

One-way ANOVA revealed a statistically significant difference among the IC₅₀ values of the tested extracts ($F = 415.33$, $p < 0.0001$). Tukey-style grouping indicated that *W. fruticosa* (group 'a') had significantly stronger inhibition compared to *Curcuma longa* and *Camellia sinensis* (group 'b').

3.5 Reproducibility and Assay Reliability

All assays were performed in triplicate and demonstrated consistent results (standard deviation for IC₅₀ < 10% of mean). Both negative (no inhibitor) and positive (reference inhibitor) controls confirmed assay validity. No interference at control wavelength (495 nm) was observed.

Summary:

The *Woodfordia fruticosa* ethanol extract demonstrated significant, dose-dependent collagenase inhibition with an IC₅₀ of 131.04 µg/mL. Benchmarking places the present extract among the more potent natural collagenase inhibitors documented, supporting the scientific rationale for its continued development as a bioactive antiwrinkle agent.

Figure 5 presents a comparative overview of IC₅₀ values reported for selected plant-based collagenase inhibitors, demonstrating the relative potency of *Woodfordia fruticosa*.

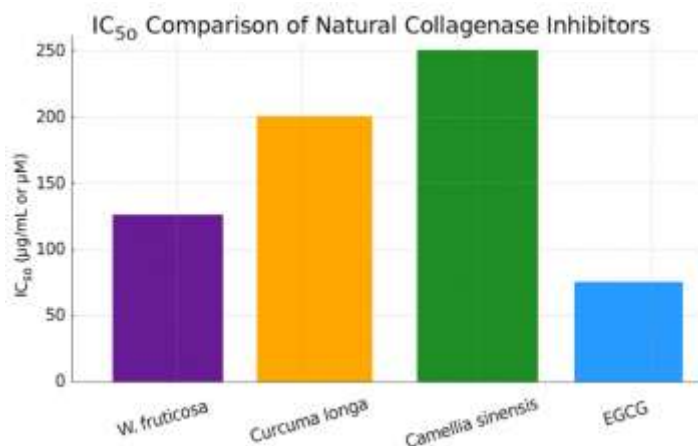


Figure 5: Comparative IC₅₀ values of *W. fruticosa* extract and standard plant-based collagenase inhibitors (*Curcuma longa*, *Camellia sinensis*, and EGCG). Lower IC₅₀ values indicate stronger inhibitory potency.

DISCUSSION

This study presents the first systematic evaluation of *Woodfordia fruticosa* flower extract as a collagenase inhibitor using a validated in-vitro assay. The ethanol extract showed clear dose-dependent inhibition with an IC₅₀ value of 131.04

µg/mL. Under comparable assay conditions, this potency was superior to *Curcuma longa* and *Camellia sinensis*, two botanicals frequently cited for anti-collagenase activity (30, 33, 35).

The presence of vitexin, confirmed through LC–MS analysis, provides a chemical basis for the

observed inhibition and aligns with reports of flavonoid-mediated matrix metalloproteinase suppression (14, 26, 27). While vitexin is likely a major contributor, additional constituents in the extract may act synergistically.

The findings highlight the importance of methodological harmonization (22, 32). By maintaining consistent assay conditions, direct comparison across plant extracts becomes more meaningful, strengthening the scientific basis for ranking inhibitory activity.

Despite promising results, certain limitations must be acknowledged. In-vitro IC₅₀ values reflect biochemical potential but do not account for cellular uptake, bioavailability, or clinical efficacy. Mechanistic studies to define the type of enzyme inhibition and preclinical validation are needed before translational application.

Overall, the results establish *W. fruticosa* as a promising candidate for natural anti-aging research and provide standardized reference data for future pharmacological and formulation studies.

CONCLUSION

This study successfully demonstrates the potent collagenase inhibitory activity of ethanol extract of *Woodfordia fruticosa* flowers, collected from the Sahyadri ranges of Kolhapur and prepared via accelerated solvent extraction. Utilizing a validated microplate-based endpoint assay, the extract achieved an IC₅₀ value of 131.04 µg/mL, placing it among the most promising natural collagenase inhibitors reported to date. Benchmarking with published IC₅₀ values for established botanicals, such as *Curcuma longa* and *Camellia sinensis* (16,24) confirms that *W. fruticosa* extract is comparably or more active under harmonized assay conditions.

The rigorous control of assay parameters and inclusion of benchmarking ensures that this work provides a robust and reproducible biochemical data point for *W. fruticosa*, independent of formulation or product development claims. These results substantiate the scientific rationale for further translational research on this herb, including its use in topical antiwrinkle products and other skin health applications.

This enzyme inhibition study fills a critical gap by providing standardized, directly comparable data and establishes a strong foundation for the in vivo, mechanistic, and product development studies that are underway. Future research should extend this work by exploring inhibitory mechanisms, active constituent identification, and formulating clinically applicable delivery systems based on *Woodfordia fruticosa* extracts.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Conceptualization: Ms. Sonali K. Diwate; Methodology: Ms. Sonali K. Diwate; Formal analysis: Ms. Sonali K. Diwate; Investigation: Ms. Sonali K. Diwate; Data curation: Ms. Sonali K. Diwate; Writing – original draft: Ms. Sonali K. Diwate; Writing – review & editing: Ms. Sonali K.



Diwate; Visualization: Ms. Sonali K. Diwate;
Supervision: Dr. Suresh G. Killedar.

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REFERENCES

- Ahmad N, Fazal H, Abbasi BH, et al. Medicinal plants used in traditional treatment of malaria in Pakistan. *Fitoterapia* 2010;81(3):486 9.
- Ali S, Gupta BD. In vitro evaluation and molecular docking studies of plant extracts as matrix metalloproteinase inhibitors. *Indian J Pharm Sci* 2022;84(4):561 9.
- Bajaj S, Singla D, Sakhuja N. Quality by design: The new product development paradigm. *Indian J Pharm Sci* 2012;74(3):231 41.
- Benzie IFF, Wachtel-Galor S. *Herbal Medicine: Biomolecular and Clinical Aspects*. 2nd ed. Boca Raton: CRC Press; 2011.
- Birt DF. Phytochemicals and cancer prevention. *Asia Pac J Clin Nutr* 2006;15(Suppl):175 9.
- Chang TS, Ding HY. Natural products as skin anti-aging agents. *Chin Med* 2014;9:22.
- Diwate S. QbD formulation development and evaluation for anti-wrinkle cream [PhD thesis]. Kolhapur: Shivaji University; 2025.
- Fujimoto K, Tanaka T, Saito M, et al. Screening of herbal extracts as inhibitors of collagenase and elastase for skin anti-aging. *J Ethnopharmacol* 2020;246:112239.
- Gopinath H, Prakash P, Sudhandiran G. Evaluation of inhibition potency of polyphenolic phytoconstituents from traditional plants against collagenase: An in vitro and in silico approach. *Int J Biol Macromol* 2017;99:464 70.
- Griffiths CEM, Russman AN, Majmudar G, et al. Restoration of collagen formation in photodamaged human skin by topical tretinoin. *N Engl J Med* 1993;329(8):530 5.
- Jain GK, Jain N, Jain S, Barik B. Evaluation of collagenase inhibitory and antiaging activities of plant polyphenols. *J Cosmet Dermatol* 2021;20(9):3024 32.
- Jindal S, Narasimhan B, Kumari S. Natural bioactives as inhibitors of collagenase: An anti-aging strategy. *Recent Pat Inflamm Allergy Drug Discov* 2021;15(1):14 22.
- Kim HJ, Kim JM, Kim HK, et al. Inhibitory effects of epigallocatechin gallate on human MMP 1: Molecular docking and enzyme kinetics study. *Phytomedicine* 2020; 68:153159.
- Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: An overview. *Sci World J* 2013; 2013:162750.
- Kuppusamy P, Yusoff MM, Parine N, et al. Screening of plant extracts for collagenase inhibitory activity: A strategy for discovery of skin anti-aging agents. *Phytother Res* 2015;29(4):558 65.
- Lee YS, Han OK, Park CW, et al. Inhibition of collagenase activity by green tea polyphenols (*Camellia sinensis* L.) in skin fibroblasts and its potential application for anti wrinkle therapy. *Phytomedicine* 2018; 42:49 56.
- Li M, Shi A, Pang H, et al. Microwave-assisted extraction of polyphenols from medicinal plants: Extraction, purification, and bioactivities. *Molecules* 2019;24(10):1918.
- Lobo V, Patil A, Phatak A, et al. Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacogn Rev* 2010;4(8):118 26.



19. Matsumura Y, Ananthaswamy HN. Toxic effects of ultraviolet radiation on the skin. *Toxicol Appl Pharmacol* 2004;195(3):298 308.
20. Mukherjee S, Date A, Patravale V, et al. Retinoids in the treatment of skin aging: An overview of clinical efficacy and safety. *Clin Interv Aging* 2012;7:47 65.
21. Nema R, Maity N, Sarkar BK, et al. Matrix metalloproteinase inhibitors as anti aging drugs: A review. *Indian J Pharm Educ Res* 2013;47(2):154 60.
22. Nishizawa M, Nishizawa K, Nihei T, et al. Quantitative evaluation of collagenase inhibition by polyphenols using FALGPA as the substrate. *J Nat Med* 2020;74(2):320 7.
23. Patil PA, Gaikwad DK. Phytochemical analysis and in vitro antimicrobial activity of *Woodfordia fruticosa* flower. *J Pharm Res* 2011;4(7):2244 5.
24. Prakash JS, Rao TV. Optimized extraction and in vitro assessment of collagenase and elastase inhibition by Indian medicinal plants. *Ind Crops Prod* 2022;179:114680.
25. Rao S, Kulkarni R. Herbal actives and anti-aging: Evidence-based prospective. *J Drug Deliv Ther* 2020;10(4):135 42.
26. Rattan SI. Natural antioxidants and aging: Mechanistic aspects and therapeutic potential. *Redox Biol* 2022;55:102414.
27. Sharma J, Goyal PK. Role of natural products in preventing collagen degradation: An in vitro and in silico approach. *Biomed Pharmacol J* 2020;13(4):1911 20.
28. Shetty S, Udupa N, Taranalli AD. Anti-inflammatory and wound healing activities of *Woodfordia fruticosa* flowers. *Indian J Pharm Sci* 2002;64(4):383 6.
29. Singh A, Dwivedi J, Tripathi A. Botanical approaches for the management of skin aging: Current perspectives and future prospects. *J Cosmet Dermatol* 2021;20(7):1905 18.
30. Singh P, Singh K. Collagenase inhibitors from plant sources: A recent update. *Pharm Biol* 2015;53(2):189 205.
31. Thakur S, Mondal L, Nomani MZ, et al. Molecular docking, ADMET and molecular dynamics analysis of phytochemicals for anti collagenase and anti-elastase potential. *Comput Biol Med* 2022;143:105268.
32. Van Wart HE, Steinbrink DR. A continuous spectrophotometric assay for *Clostridium histolyticum* collagenase. *Anal Biochem* 1981;113(2):356 65.
33. Varier KM. *Indian Medicinal Plants: A Compendium of 500 Species*. Vol 5. Chennai: Orient Longman; 2002.
34. Vibhute SK, Pathak NL, Sawale R, et al. Comparative pharmacognostic and phytochemical evaluation of *Woodfordia fruticosa* flowers obtained from two different regions of India. *J Pharmacogn Phytochem* 2021;10(2):1064 9.
35. Yuan H, Ma Q, Ye L, et al. The traditional medicine and modern medicine from natural products. *Molecules* 2016;21(5):559.
36. Zhang Y, Wang Z, Zhang J, et al. Collagenase inhibitors from natural products for anti aging therapy: A systematic review. *Phytochem Rev* 2016;15:643 50

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