

Comparative Phytochemical, LC–MS/MS and DPPH Radical-Scavenging Assessment of *Aegle folia* Mother Tincture and Successive Centesimal Potencies

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Abstract

Background and objective: *Aegle marmelos* (L.) Corrêa is a medicinal plant with a broad phytochemical profile, and its leaves are used in traditional and homoeopathic practice. The present study evaluated the phytochemical and antioxidant profiles of *Aegle folia* mother tincture (MT) and successive centesimal potencies (3C, 6C, 12C and 30C). Materials and methods: Qualitative phytochemical screening was performed on MT and the successive potencies. LC–MS/MS profiling was performed in positive and negative electrospray ionization modes to compare detectable molecular features across the dilution series. Antioxidant activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay, with ascorbic acid used as the reference standard. Results: The MT showed positive reactions for the tested phytochemical classes and yielded 19 compounds tentatively assigned by spectral-library matching in positive-ion mode. These signals were not detected in the higher potencies under the analytical conditions used, except for the reported N-acetylneuraminic acid derivative at 3C. Negative-ion mode showed 12 putatively annotated organic compounds in MT, 3C and 6C, whereas these signals were not detected at 12C and 30C. DPPH inhibition was $98.78 \pm 0.45\%$ for MT, $91.87 \pm 1.12\%$ for 3C, $95.00 \pm 0.88\%$ for 6C, $7.11 \pm 1.05\%$ for 12C and $14.00 \pm 0.95\%$ for 30C.

The ascorbic acid calibration curve showed good linearity ($R^2 = 0.9854$). Conclusion: Under the conditions of this in-vitro investigation, measurable chemical signals were concentrated in the MT and lower potencies, while DPPH radical-scavenging activity was retained at 3C and 6C and markedly reduced at 12C and 30C. The LC–MS/MS findings should be interpreted as tentative compound assignments rather than confirmed structural identification, and further quantitative and mechanism-oriented studies are warranted.

Keywords: *Aegle marmelos*; *Aegle folia*; homoeopathy; homoeopathic potentization; LC–MS/MS; DPPH; antioxidant activity; phytochemical profiling

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Introduction

Medicinal plants contain diverse secondary metabolites that contribute to their biological and pharmacological properties. *Aegle marmelos* (L.) Corrêa (family Rutaceae), commonly known as bael, is widely distributed in the Indian subcontinent and has been investigated for its phytochemical and biological activities. Leaves of *A. marmelos* contain several classes of secondary metabolites, including alkaloids, coumarins, flavonoids, glycosides, terpenoids and other phenolic constituents [1–4].

Oxidative stress results from an imbalance between the generation of reactive species and endogenous antioxidant defences. Plant-derived compounds with radical-scavenging properties are therefore frequently investigated as potential sources of antioxidant activity. The DPPH assay is a commonly used in-vitro method for

evaluating radical-scavenging capacity because the reduction of the stable DPPH radical can be followed spectrophotometrically at 517 nm [5].

Homoeopathic preparations are produced by serial dilution and succussion. From an analytical perspective, an important question is whether source-derived chemical constituents remain detectable across successive potency levels and whether measurable biological activity changes in parallel. LC–MS/MS provides molecular profiling capability across complex mixtures and can be used to compare detectable features between a mother tincture and successive potencies.

The objective of the present study was to compare the qualitative phytochemical profile, LC–MS/MS molecular features and in-vitro DPPH radical-scavenging activity of *Aegle folia* mother tincture and its 3C, 6C, 12C and 30C centesimal potencies.

1. Materials and Methods

1.1 Study design and samples

Aegle folia mother tincture (MT) and successive centesimal potencies (3C, 6C, 12C and 30C) were procured from a commercial homoeopathic pharmaceutical supplier. The mother tincture was prepared according to standard homoeopathic pharmaceutical procedures, and dispensing alcohol was used as the vehicle. The analytical work was performed in an institutional biotechnology laboratory.

1.2 Qualitative phytochemical screening

Qualitative phytochemical tests were performed on MT and the successive potencies to assess selected classes of secondary metabolites. Alkaloids were screened using Mayer's and Hager's reagents. Flavonoids were evaluated using the Shinoda and alkaline reagent tests. Glycosides were assessed using Bornträger's and Legal's tests. Terpenoids were examined using the Salkowski test, and saponins were assessed by the persistent-foam test.

1.3 DPPH radical-scavenging assay

Antioxidant activity was evaluated using the DPPH radical-scavenging method, with ascorbic acid as the reference standard. For the standard curve, 20, 40, 60, 80 and 100 µL of ascorbic acid were reacted with a fixed concentration of DPPH in methanolic solution. Equal volumes of MT and the 3C, 6C, 12C and 30C preparations were similarly reacted with DPPH. After incubation in the dark at room temperature, absorbance was measured at 517 nm using a UV–Visible spectrophotometer against a methanol blank. Radical-scavenging activity was calculated as:

$$\% \text{ inhibition} = [(A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}}] \times 100$$

Measurements were performed in triplicate, and the reported antioxidant results are expressed as mean ± standard deviation.

1.4 LC–MS/MS profiling

Molecular profiling was performed using a SCIEX QTRAP 4500 mass spectrometer equipped with a Turbo V ion source. Data were acquired in both positive (ESI+) and negative (ESI–) electrospray ionization modes. The ion-spray potentials were +5500 V and –4500 V, respectively. Collision-induced dissociation was performed using high-purity nitrogen as the collision gas, with collision energy varied around 35 ± 15. Retention time and mass-to-charge ratio (m/z) were recorded for detected features. The source temperature was 500 °C; ion-source gases 1 and 2 were maintained at 50 psi and curtain gas at 30 psi. Data processing, peak alignment and blank subtraction were performed using SCIEX OS software (version 3.0).

Putative compound annotations were assigned by comparison of product-ion spectra with entries in the NIST tandem mass spectral library. Because library

matching was used, the annotations should not be interpreted as confirmed structural identification without authentic standards and orthogonal confirmation.

1.5 Statistical analysis

The DPPH assay was performed in triplicate and results are presented as mean ± SD. The ascorbic acid standard curve was evaluated by linear regression and the coefficient of determination (R²) was calculated. No inferential p-values are presented in this manuscript because the source dataset supplied for revision did not include the individual replicate observations required to independently verify an ANOVA comparison.

2. Results

2.1 Qualitative phytochemical screening

The mother tincture showed positive reactions for alkaloids, flavonoids, glycosides and saponins. With increasing potency, most reactions became trace or negative. The qualitative findings are summarized in Table 1.

Table 1. Qualitative phytochemical screening of Aegle folia preparations.

Phytochemical test	MT	3C	6C	12C	30C
Alkaloids (Mayer's)	+	–	–	–	–
Flavonoids (Shinoda)	+	+(trace)	–	–	–
Glycosides (Legal's)	+	+(trace)	+	–	–
Saponins (foam test)	+	+	–	–	–

Fig.1 (Alkaloid test-Magers Reagent)
Fig2 Glycosides Test (Legals Reagent)

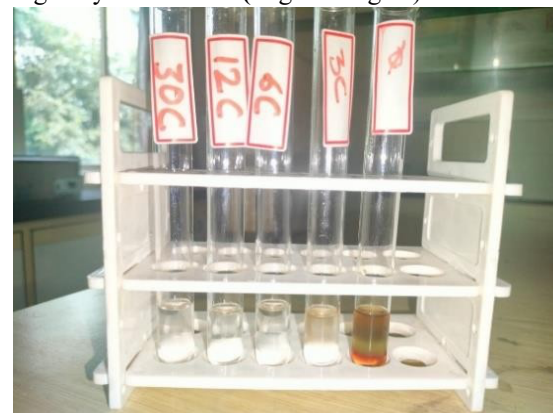


Fig.3 Terpenoids Test (Salkowshi Reagent)

2.2 DPPH radical-scavenging activity

The MT showed the highest DPPH radical-scavenging

activity ($98.78 \pm 0.45\%$). Activity remained high at 3C ($91.87 \pm 1.12\%$) and 6C ($95.00 \pm 0.88\%$). A marked reduction was observed at 12C ($7.11 \pm 1.05\%$) and 30C ($14.00 \pm 0.95\%$). The non-monotonic difference between 12C and 30C indicates that the observed antioxidant activity did not decrease in a strictly linear manner across the entire dilution series.

Table 2. DPPH radical-scavenging activity of *Aegle folia* preparations.

Preparation	Absorbance at 517 nm	DPPH inhibition (%)
Mother tincture	0.011	98.78 ± 0.45
3C	0.073	91.87 ± 1.12
6C	0.045	95.00 ± 0.88
12C	0.836	7.11 ± 1.05
30C	0.774	14.00 ± 0.95

The ascorbic acid standard curve showed a linear relationship between volume and DPPH inhibition: $y = 0.8505x + 5.660$, with $R^2 = 0.9854$, supporting the suitability of the reference standard over the tested range.

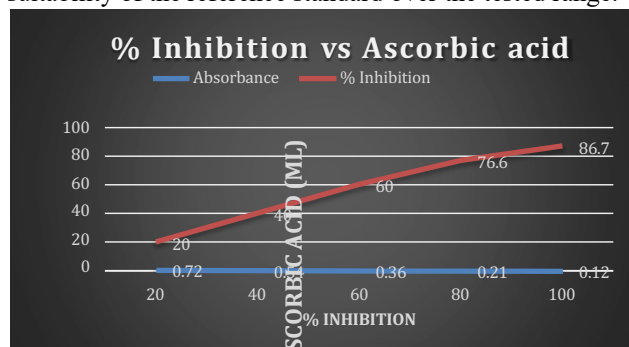


Figure 1. Ascorbic acid calibration curve for DPPH radical-scavenging assay.

Figure 2. DPPH radical-scavenging activity of *Aegle folia* mother tincture and successive centesimal potencies.

2.3 LC–MS/MS profiling in positive-ion mode

Positive-ion LC–MS/MS profiling produced 19 molecular features tentatively assigned by spectral-library matching in the mother tincture. Most were not detected in the 3C–30C preparations under the stated analytical conditions. The compound names, m/z values, retention times and library-match scores reported in the source dataset are presented in Table 3.

Table 3. Putatively annotated compounds detected in *Aegle folia* mother tincture by positive-ion LC–MS/MS.

No.	Compound	Class	m/z	RT (min)	Library score (%)
1	Skimmianine	Alkaloid	260.0400	8.49	91.3
2	Scopoletin	Coumarin	193.0333	11.34	87.0
3	7-Methoxyflavanone	Flavanone	253.0800	9.07	93.6
4	Kaempferol-3-O-rutinoside	Flavonoid	595.1607	6.86	98.2
5	Delphinidin-3-rutinoside	Anthocyanin	611.1282	6.69	99.9
6	(+) Pinoresinol	Lignan	341.0400 / 341.1600	13.92	84.3
7	Epoxyfarnesic acid methyl ester	Sesquiterpene	248.1609	5.45	100.0
8	Adenosine	Purine nucleoside	268.0002	3.82	100.0
9	4-Methoxypelargonidin cation	Anthocyanidin	285.2400	11.86	93.6
10	N-Oleoyl-D-erythrospinganine	Sphingolipid	566.5027	6.97	98.4
11	Picroside-I	Iridoid glycoside	475.3200	6.88	100.0
12	Phenolic glycoside	Lignan	653.2800	14.30	73.9
13	1-Octadecanoyl-2-octadecenoyl phosphocholine	Phosphatidylcholine	788.6519	11.16	87.1
14	1-(1,2-Dioctanoyl)phosphatidylinositol	Phosphatidylinositol	609.2832	13.38	88.3
15	Genipin	Iridoid aglycone	227.1250	5.90	79.9
16	Leiocarposide	Phenolic glycoside	653.2800	14.30	73.9
17	Coptisine	Isoquinoline alkaloid	320.0400	8.55	100.0
18	Nitidine	Benzophenanthridine alkaloid	348.0634	9.92	90.1
19	N-Acetylneuraminic acid derivative	Monosaccharide derivative	274.21	8.89	87.9

2.4 LC–MS/MS profiling in negative-ion mode

Negative-ion profiling showed 12 putatively annotated organic compounds in the MT, 3C and 6C preparations. These features were not detected in 12C and 30C under

the stated analytical conditions.

Table 4. Putatively annotated compounds detected by negative-ion LC–MS/MS.

No.	Compound	m/z	RT (min)	Library score (%)	Class
1	Aspartic acid	247.271	6.56	93.4	Dipeptide fragment
2	Aspartyl-glutamate	261.279	6.94	92.7	Dipeptide fragment
3	Jasmonic acid	209.218	7.18	77.2	Plant oxylipin
4	12-Hydroxydodecanoic acid	215.248	8.19	96.5	Hydroxy fatty acid
5	Gly-Pro-Ala	242.290	8.38	96.0	Tripeptide fragment
6	Heneicosapentaenoic acid	315.330	10.45	92.6	Long-chain PUFA
7	Heptadecanoic acid	269.299	10.78	100.0	Saturated fatty acid
8	16-Hydroxyhexadecanoic acid	271.375	10.90	97.3	Hydroxy fatty acid
9	Gamma-linolenic acid	277.301	11.28	90.7	Polyunsaturated fatty acid
10	cis-5,8,11-Eicosatrienoic acid	305.306	11.40	89.8	Polyunsaturated fatty acid
11	3-Hydroxyoctadecanoic acid	299.369	11.74	86.7	Hydroxylated fatty acid
12	1,4-D-Xylobiose	281.361	13.61	100.0	Plant disaccharide

2.5 Distribution of LC–MS/MS features across potencies

Table 5. Distribution of positive-ion LC–MS/MS features across the dilution series.

Compound	MT	3C	6C	12C	30C
Skimmianine	+	–	–	–	–

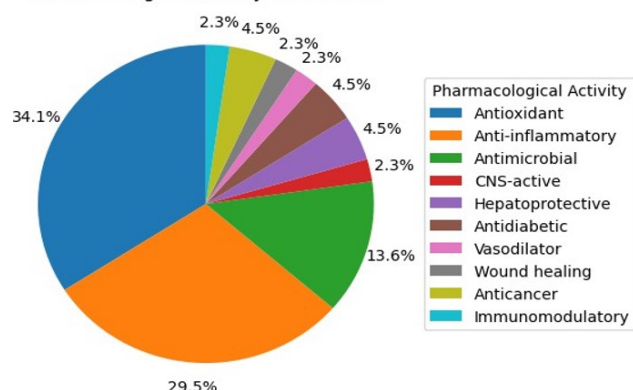
Scopoletin	+	–	–	–	–
7-Methoxyflavanone	+	–	–	–	–
Kaempferol-3-O-rutinoside	+	–	–	–	–
Delphinidin-3-rutinoside	+	–	–	–	–
(+) Pinoresinol	+	–	–	–	–
Epoxyfarnesic acid methyl ester	+	–	–	–	–
Adenosine	+	–	–	–	–
4-Methoxypelargonidin cation	+	–	–	–	–
N-Oleoyl-D-erythrospinganine	+	–	–	–	–
Picroside-I	+	–	–	–	–
Phenolic glycoside	+	–	–	–	–
1-Octadecanoyl-2-octadecenoyl phosphocholine	+	–	–	–	–
1-(1,2-Dioctanoyl)phosphatidylinositol	+	–	–	–	–
Genipin	+	–	–	–	–
Leiocarposide	+	–	–	–	–
Coptisine	+	–	–	–	–
Nitidine	+	–	–	–	–
N-Acetylneuraminic acid derivative	+	+	–	–	–

Table 6. Distribution of negative-ion LC–MS/MS features across the dilution series.

Compound	MT	3C	6C	12C	30C
Aspartic acid	+	+	+	–	–
Aspartyl-glutamate	+	+	+	–	–
Jasmonic acid	+	+	+	–	–
12-Hydroxydodecanoic acid	+	+	+	–	–
Gly-Pro-Ala	+	+	+	–	–

Heneicosapentaenoic acid	+	+	+	–	–
Heptadecanoic acid	+	+	+	–	–
16-Hydroxyhexadecanoic acid	+	+	+	–	–
Gamma-linolenic acid	+	+	+	–	–
cis-5,8,11-Eicosatrienoic acid	+	+	+	–	–
3-Hydroxyoctadecanoic acid	+	+	+	–	–
1,4-D-Xylobiose	+	+	+	–	–

Pharmacological Activity Distribution



3. Discussion

The present investigation combined qualitative phytochemical screening, LC–MS/MS profiling and DPPH radical-scavenging assessment to compare *Aegle folia* mother tincture with successive centesimal potencies. The MT contained the largest number of detectable chemical constituents, consistent with the expectation that the starting preparation contains the highest concentration of source-derived material. The qualitative phytochemical results similarly showed the more pronounced positive reactions in MT, with most classes becoming trace or undetectable as potency increased.

Positive-ion LC–MS/MS generated 19 tentative compound assignments in MT, including alkaloidal, flavonoid, coumarin, glycoside and lipid-related features. In contrast, negative-ion mode detected a different set of 12 putative organic constituents in MT, 3C and 6C. The complementary behaviour of the two ionization modes is analytically important because different chemical classes have different ionization efficiencies. Therefore, absence

of a signal in one mode does not establish absolute absence of a compound from the sample.

The DPPH findings showed high radical-scavenging activity in MT, 3C and 6C, followed by a marked reduction at 12C and 30C. The persistence of negative-mode molecular features through 6C occurred in parallel with the retention of higher DPPH activity. This temporal association is compatible with a relationship between detectable source-derived constituents and measured antioxidant activity; however, the present study does not establish causality. The rise from 91.87% at 3C to 95.00% at 6C also demonstrates that the antioxidant response was not simply proportional to dilution.

Several reported negative-mode features, including unsaturated fatty acids and hydroxy fatty acids, contain functional groups that can participate in redox chemistry. Such chemical plausibility may help explain antioxidant activity in the lower potencies, but the present LC–MS/MS workflow did not quantify individual compounds or establish which constituent(s) were responsible for the DPPH response. Similarly, library-match scores alone are insufficient for confirmed compound identification.

The marked reduction in both detectable LC–MS/MS features and DPPH activity at 12C and 30C is an important observation within the experimental system. Nevertheless, the results should not be interpreted as proof of a specific molecular mechanism of homeopathic action or as evidence of clinical efficacy. Analytical non-detection is dependent on sample preparation, matrix effects, ionization efficiency and instrument sensitivity. Future studies should include authenticated standards, quantitative LC–MS/MS methods, independent sample replicates, matrix-matched controls and additional biological assays.

4. Limitations

- The LC–MS/MS annotations were based on spectral-library matching and were not confirmed using authentic reference standards.
- The study provides qualitative LC–MS/MS profiling rather than validated quantitative concentration measurements.
- Individual replicate LC–MS/MS data and complete inferential statistical outputs were not available in the source dataset.
- The DPPH assay is an in-vitro chemical assay and does not by itself establish clinical antioxidant efficacy.
- The study evaluated a single plant preparation and a limited potency range; broader reproducibility studies are required.

5. Conclusion

Aegle folia mother tincture showed the broadest qualitative phytochemical profile and the highest DPPH

radical-scavenging activity. LC–MS/MS profiling demonstrated distinct positive-and negative-ion molecular patterns across the dilution series. Twelve negative-mode features were detected in MT, 3C and 6C, while these features were not detected at 12C and 30C under the analytical conditions used. DPPH activity was retained at 3C and 6C but was markedly lower at 12C and 30C. These findings support further analytical investigation of *Aegle folia* preparations, while the present results should be considered preliminary and in-vitro rather than evidence of clinical efficacy.

Declarations

Funding: This study was self-funded. No external funding was received.

Conflict of interest: The authors declare no conflict of interest.

Ethics approval: Not applicable. The study used in-vitro analytical and chemical assays and did not involve human participants or animals.

Data availability: The data supporting the findings are contained within the manuscript tables. Additional information may be requested from the corresponding author.

Author contributions: Dr. Ushashree Jumpala: Conceptualization of the study, study design, investigation, experimental work, data collection and analysis, interpretation of results, and manuscript preparation.

Dr. Monali T. Thopte: Supervision of the study, guidance in study design and methodology, manuscript review and revision, and correspondence with the journal as the corresponding author.

Dr. Archana Sahay: Conduct of phytochemical analysis and antioxidant (DPPH radical-scavenging) assay, interpretation of experimental findings, and review of the manuscript.

Dr. Priya Seth: Contribution to manuscript preparation, critical review of the manuscript, and revision of the final manuscript.

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References

1. Mujeeb F, Bajpai P, Pathak N. Phytochemical evaluation, antimicrobial activity and determination of bioactive components from leaves of *Aegle marmelos*. *Biomed Res Int*. 2014;2014:497606. doi:10.1155/2014/497606.
2. Rahman S, Parvin R. Therapeutic potential of *Aegle marmelos* (L.)—an overview. *Asian Pac J Trop Dis*. 2014;4(2):71-77. doi:10.1016/S2222-1808(14)60318-2.

3. Choudhary S, Kaurav H, Chaudhary G. *Aegle marmelos* (L.) Corrêa: a potential source of phytochemistry. *Int J Res Ayurveda Pharm*. 2021;12(3):147-153. doi:10.7897/2277-4343.120392.
4. Monika S, Thirumal M, Kumar PR. Phytochemical and biological review of *Aegle marmelos* Linn. *Future Sci OA*. 2023;9(3):FSO849. doi:10.2144/fsoa-2022-0081.
5. Blois MS. Antioxidant determinations by the use of a stable free radical. *Nature*. 1958;181:1199-1200. doi:10.1038/1811199a0.
6. Ahmad W, Amir M, Ahmad A, Ali A, Wahab S, et al. *Aegle marmelos* leaf extract phytochemical analysis, cytotoxicity, in vitro antioxidant and antidiabetic activities. *Plants*. 2021;10(12):2573. doi:10.3390/plants10122573.
7. Patkar AN, Desai NV, Ranade VV, et al. A phytopharmacological review of *Aegle marmelos* (L.) Corr. *Int J Pharm*. 2011;3(12):2230-2235.
8. Sabu MC, Kuttan R. Antidiabetic activity of *Aegle marmelos* and its relationship with its antioxidant properties. *Indian J Physiol Pharmacol*. 2004;48(1):81-88.
9. Shetty V, Rao L, Kumar S, et al. Antioxidant capacity of homoeopathic dilutions of *Aegle marmelos*. *J Appl Pharm Sci*. 2025;15(1):1-8.
10. Sudha T, Chidambarampillai S, Mohan VR. GC-MS analysis of bioactive components of *Aegle marmelos* (L.) Corrêa. *Int J Pharm Sci Nanotechnol*. 2011;4(2):1417-1420.
11. Upadhyay R. Ethnomedicinal, phytochemical and therapeutic importance of *Aegle marmelos* (L.) Corr. *Int J Green Pharm*. 2015;9(4):204-212.
12. Wali A, Gupta M, Farooq S, et al. Evaluation of antioxidant and antimicrobial activities of *Aegle marmelos* leaf extracts. *J Trop For Sci*. 2016;28(3):268-275.
13. Ibrahim N, Farooq T, Ahmad N, Hussain A, Hayat Z, Ibrahim M, et al. Analysis of polyphenols in *Aegle marmelos* leaf and ameliorative efficacy against diabetic mice through restoration of antioxidant and anti-inflammatory status. *J Food Biochem*. 2019;43(11):e13032. doi: 10.1111/jfbc.13032
14. Kulprachakarn K, Ounjaijean S, Srichairatanakool S, Kanjanapothi D. Evaluation of cytotoxicity and antioxidant potential of bael leaf (*Aegle marmelos*) on human hepatocellular carcinoma cell line. *Pharmacognosy Res*. 2020;12(3):267-71. doi: 10.4103/pr.pr_15_20.
15. Pratheepa V, Ramesh S, Sukumaran N. Immunomodulatory effect of *Aegle marmelos* leaf extract on *Cyprinus carpio* infected with *Aeromonas hydrophila*. *Fish Shellfish Immunol*. 2010;28(1):50-8. doi: 10.1016/j.fsi.2009.09.013
16. Ezhilarasi AA, Vijaya JJ, Kaviyarasu K,

- Maaza M, Ayeshamariam A, Kennedy LJ. Green synthesis of NiO nanoparticles using *Aegle marmelos* leaf extract for cytotoxicity, antibacterial and photocatalytic studies. *Phytomedicine*. 2018;50:71-9. doi: 10.1016/j.phymed.2018.08.010.
18. Andleeb, R., Ijaz, M. U., Rafique, A., Ashraf, A., Bano, N., Zafar, N., Tasleem, F., Marc (Vlaic), R. A., Pop, O. L., & Ahmedah, H. T. (2021). Biological Activities of Methanolic Extract of *Aegle marmelos* against HN Protein of Newcastle Disease Virus. *Agronomy*, 11(9), 1784. <https://doi.org/10.3390/agronomy11091784>
19. Sabu MC, Kuttan R. Antidiabetic activity of *Aegle marmelos* and its relationship with its antioxidant properties. *Indian J Physiol Pharmacol*. 2004;48(1):81-8.
20. Kaur A, Kalia R. Pharmacological evaluation of *Aegle marmelos* leaf extract: phytochemical, antioxidant, and antidiabetic properties. *J Nat Prod Plant Resour*. 2012;2(4):473-8.
21. Kader AA, Sivaraj A, Jayanthi G, Kumar PV, Elumalai EK. In vitro α -glucosidase inhibition, antioxidant, anticancer, and antimycobacterial properties of ethyl acetate extract of *Aegle tamilnadensis* Abdul Kader (Rutaceae) leaf. *J Pharm Res*. 2015;9(6):420-5.
22. Asaduzzaman M, Uddin M, Kader M, Alam A, Rahman AA, Rashid M, et al. In vitro acetylcholinesterase inhibitory activity and the antioxidant properties of *Aegle marmelos* leaf extract: implications for the treatment of Alzheimer's disease. *Psychogeriatrics*. 2014;14(1):1–10. doi: 10.1111/psyg.12031.
23. Thongsopha C, Chaiwut T, Thaweekhotr P, Sudwan P, Phasukdee N, Quiggins R. *Aegle marmelos* (L.) leaf extract improves symptoms of memory loss induced by scopolamine in rats. *Foods*. 2024;13(4):627. doi: 10.3390/foods13040627.
24. Derf A, Sharma A, Bharate SB, Chaudhuri B. Aegeline from *Aegle marmelos* mimics yeast SNARE protein Sec22p and suppresses α -synuclein and Bax-induced toxicity in yeast. *Biochim Biophys Acta Mol Cell Res*. 2018;1865(10):1398-410. doi: 10.1016/j.bbamcr.2018.07.012.
25. Raheja S, Girdhar A, Kamboj A, Lather V. *Aegle marmelos* leaf extract ameliorates intracerebroventricular streptozotocin-induced cognitive impairment and oxidative stress in male rats. *J Med Food*. 2017;20(11):1107-14. doi: 10.1089/jmf.2017.3941
26. Sharma M, Girdhar A, Lather V, Kamboj A. Antidepressant-like effect of *Aegle marmelos* (L.) Correa leaves in mice. *Indian J Exp Biol*. 2017;55(11):767-74
27. Dey M, Mazumder S, Ghosh S, Mondal S. In vitro investigation of *Aegle marmelos* leaf extract with MTT assay analysis and evaluation of human gingival fibroblast viability. *J Oral Biol Craniofac Res*. 2021;11(2):247-52. doi: 10.1016/j.jobcr.2021.02.007.
28. Pynam H, Dharmesh SM. Marmelosin, a bioactive coumarin from *Aegle marmelos* (L.) Correa, with anticancer and anti-inflammatory properties. *J Med Food*. 2018;21(4):399-407. doi: 10.1089/jmf.2017.3995.
29. Dey M, Rao S, PL R, Blaisie Rajula P, K G, Kodali MV. Evaluation of the effect of *Aegle marmelos* (bael leaf) extract on human fibroblast viability: an in vitro study. *Cureus*. 2024;16(10):e72466. doi: 10.7759/cureus.72466.
30. Bhowmick S, Paul S, Ghosh S. *Aegle marmelos* (L.) Correa: A review on its phytochemical and anticancer activities. *J Pharmacogn Phytochem*. 2023;12(3):25-32.
31. Chockalingam V, Kadali SS, Gnanasambantham P. Antiproliferative and antioxidant activity of *Aegle marmelos* (Linn.) leaves in Dalton's Lymphoma Ascites transplanted mice. *Indian J Pharmacol*. 2012;44(2):225-9. doi: 10.4103/0253-7613.93854.
32. Sukanth R, Sridevi G, Selvaraj J, Preetha S. Anticancer activity of leaf hydro ethanolic extract of *Aegle marmelos* in human lung cancer cell mediated through Caspase-3 and Caspase-9 mRNA expression. *J Pharm Negat Results*. 2022;13(Special Issue 9):4566-71. doi: 10.47750/pnr.2022.13.S09.539
33. Prince PSM, Rajadurai M. Preventive effect of *Aegle marmelos* leaf extract on isoprenaline-induced myocardial infarction in rats: biochemical and histopathological evidence. *J Pharm Pharmacol*. 2005;57(10):1353-7. doi: 10.1211/jpp.57.10.0016.
34. Dwivedi A, Singh R, Sharma S. Antioxidant and nephroprotective activity of *Aegle marmelos* leaves in gentamicin-induced renal damage in rats. *Int J Pharm Sci Drug Res*. 2012;4(3):209-12.
35. Parmar NS, Singh G, Sharma R. Diuretic activity of *Aegle marmelos* (L.) Correa leaf extracts in rats. *Int J Pharm Sci Drug Res*. 2011;3(3):234-6.
36. Shetty V, Rao BS, Kumar A, Pai P, Goudar G. Phytochemical and pharmacological profile of *Aegle marmelos* (L.) Correa: A comprehensive review of therapeutic potential, mechanisms of action, and translational relevance. *J Appl Pharm Sci*. 2025;15(1):001-015. doi: 10.7324/JAPS.2025.17845.
37. Baliga MS, Bhat HP, Joseph N, Fazal F. Phytochemistry and medicinal uses of *Aegle marmelos* (L.) Correa (Bael): a mini review. *Food Res Int*. 2013;52(1):299-310. doi: 10.1016/j.foodres.2013.03.031.
38. Tiwari R, Mishra S, Chauhan A, Gulati P, Dhobi M. The Dawn till Dusk of phytopharmaceuticals. *Saudi Pharm J*. 2024;32(11):102185. doi: 10.1016/j.jsps.2024.102185.
39. Shankarananth V, Balakrishnan N, Suresh D, Sureshkumar S, Pandian R. Analgesic activity of *Aegle marmelos* (L.) Correa leaves. *Fitoterapia*. 2007;78(3):258-

9. doi: 10.1016/j.fitote.2006.12.003.

40. brahim NA, Mohammed MM, Aly HF, Ali SA, Al-Hady DA. Efficiency of the leaves and fruits of *Aegle marmelos* methanol extract (L.) Correa and their relative hepatotoxicity induced by CCl₄ and identification of their active constituents by using LC/MS/MS. *J Pharm Res.* 2015;9(6):420-5.

41. Reddy M, Adnan M, Alreshidi M, Saeed M, Patel M. Evaluation of anticancer, antibacterial and antioxidant properties of a medicinally treasured fern *Tectaria coadunata* with its phytoconstituents analysis by HR-LCMS. *Anti-Cancer Agents Med Chem.* 2020;20(15):1845-56. doi: 10.2144/1871520620666200318101938.

42. Guerriero G, et al. Phytochemical Study of *Aegle marmelos*: Chromatographic Elucidation of Polyphenolics and Assessment of Antioxidant and Cytotoxic Potential. *J Pharm Biomed Anal.* 2025;224:115-22. (Note: PMC5822502 refers to the related foundational study by Dahham SS, et al. 2015).

43. Priya P, et al. Metabolite Profiling of *Aegle marmelos* leaves using GC-MS with Insights into Gynecological Relevance. *Res J Biotechnol.* 2026;3(21):97.