Insight Bulletin: A Multidisciplinary Interlink International Research Journal
Peer Reviewed International, Open Access Journal.
ISSN : 3065-7857 / Website: https://ibrj.us / Volume-3, Issue-5 / May - 2026

Original Article

Comparative Evaluation of Hibiscus and Mussaenda-Based Natural, Mixed and Fe^{3+}-Modified Indicators

Reshma P. Divkar[1], Saloni N. Bamugade[2]
[1,2]Asst. Prof., Department of Chemistry, Dr. S. N. D. Arts, Commerce & Science College, Gove – Kolad Roha – Raigad, Maharashtra- India

Manuscript ID:
IBMIIRJ -2026-030548

Submitted: 18 Apr. 2026
Revised: 26 Apr. 2026
Accepted: 15 May 2026
Published: 31 May 2026

ISSN: 3065-7857
Volume-3
Issue-5
Pp. 257-261
May 2026

Correspondence Address:
Reshma P. Divkar
Asst. Prof., Department of Chemistry, Dr. S. N. D. Arts, Commerce & Science College, Gove – Kolad Roha – Raigad, Maharashtra- India
Email: shelkereshma@rediffmail.com

OPEN ACCESS
Quick Response Code:
Web. https://ibrj.us
DOI: 10.5281/zenodo.22124945
DOI Link:
https://doi.org/10.5281/zenodo.22124945

Abstract
The growing demand for sustainable and eco-friendly alternatives to synthetic acid–base indicators has encouraged the exploration of plant-derived pigments. This study investigates the potential of Hibiscus (Hibiscus rosa-sinensis) and Mussaenda extracts, both individually and in combination, as natural indicators, and further examines the effect of iron (III) (Fe^{3+}) modification on their performance. Hibiscus extracts, rich in anthocyanins, displayed distinct and sharp color changes from red in acidic conditions to purple and blue in alkaline solutions, making them effective for strong acid–strong base titrations. Mussaenda extracts, containing flavonoids and glycosides, produced yellow to reddish transitions, though with less precision, making them more suitable for broader but less sensitive applications. When blended, the mixed indicators provided a wider pH coverage, enhancing versatility across different titration systems. Modification with Fe^{3+} ions stabilized the pigments, intensified color changes, and reduced fading during storage, resulting in clearer endpoints and improved reproducibility. The Fe^{3+}-modified indicators demonstrated performance comparable to conventional synthetic indicators such as phenolphthalein and methyl orange. Overall, Hibiscus extracts proved to be strong candidates for precise titrations, Mussaenda extracts served as complementary options, and their mixed and Fe^{3+}-modified forms offered enhanced stability and broader applicability. These findings highlight the potential of natural, mixed, and Fe^{3+}-modified indicators from Hibiscus and Mussaenda as safe, biodegradable, and cost-effective alternatives, supporting the principles of green chemistry and providing valuable tools for educational and analytical laboratories.

Keywords: *Natural acid–base indicators, Hibiscus, Mussaenda, end point, green chemistry, Mixed plant extracts*

Introduction

Indicators are essential tools in analytical chemistry, particularly in acid–base titrations, where they signal the completion of a reaction through a visible color change. Traditionally, synthetic indicators such as phenolphthalein and methyl orange have been widely used due to their reliability and sharp transitions. However, concerns about toxicity, environmental impact, and cost have encouraged researchers to explore natural alternatives that are safe, biodegradable, and sustainable. Plant-derived pigments, especially anthocyanins and flavonoids, have emerged as promising candidates for this purpose. Hibiscus (Hibiscus rosa-sinensis) is well known for its rich anthocyanin content, which exhibits distinct color changes across varying pH levels. In acidic conditions, Hibiscus extracts appear bright red, shifting to purple and eventually blue in alkaline environments. This sharp transition makes Hibiscus a strong candidate for titrations involving strong acids and bases. On the other hand, Mussaenda species contain flavonoids and glycosides that produce yellow to reddish color changes. Although these transitions are less pronounced than those of Hibiscus, Mussaenda extracts offer broader applicability and can complement other natural in Combining Hibiscus and Mussaenda extracts creates mixed indicators that cover a wider pH range, enhancing versatility in different titration systems. Furthermore, modification of these natural pigments with iron (III) (Fe^{3+}) ions has been shown to improve their stability and performance.

How to cite this article:
Divkar, R. P., & Bamugade, S. N. (2026). Comparative Evaluation of Hibiscus and Mussaenda-Based Natural, Mixed and Fe^{3+}-Modified Indicators. InSight Bulletin: A Multidisciplinary Interlink International Research Journal, 3(5), 257–261. https://doi.org/10.5281/zenodo.22124945

The Fe^{3+} ions form complexes with anthocyanins and flavonoids, reducing pigment degradation, intensifying color changes, and providing sharper endpoints. This modification addresses one of the main limitations of natural indicators—their tendency to fade or lose effectiveness during storage. The comparative evaluation of Hibiscus, Mussaenda, mixed extracts, and Fe^{3+}-modified forms provides valuable insights into their suitability as eco-friendly alternatives to synthetic indicators. By assessing their color transition ranges, stability, and titration performance, this study contributes to the advancement of green chemistry practices. The findings highlight the potential of these plant-based indicators to replace conventional dyes in educational and analytical laboratories, offering a safer and more sustainable approach to chemical analysis.

Objectives

- To extract and study natural indicators from Hibiscus and Mussaenda plants.
- To compare their color change behavior across different pH ranges.
- To prepare mixed indicators and evaluate their effectiveness in titrations.
- To modify the extracts with Fe^{3+} ions and assess improvements in stability and accuracy.

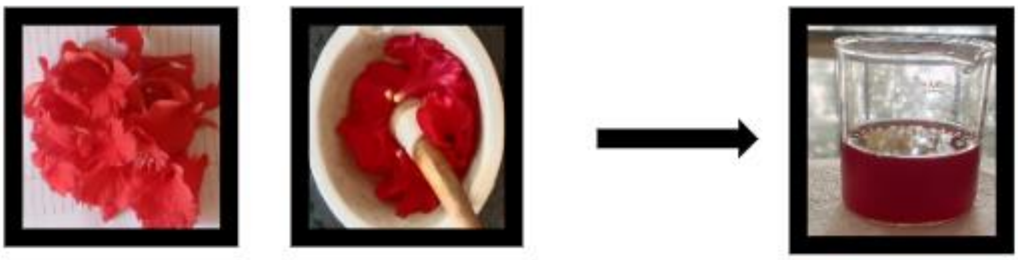
Materials And Methodology

Materials

- Hydrochloric acid (HCl)
- Sodium hydroxide (NaOH)
- Acetic acid (CH_3COOH)
- Ammonium hydroxide (NH_4OH)
- Phenolphthalein and methyl orange (synthetic indicators)
- Fresh hibiscus flowers and Mussaenda (for herbal extracts)
- Ferric chloride ($FeCl_3$)

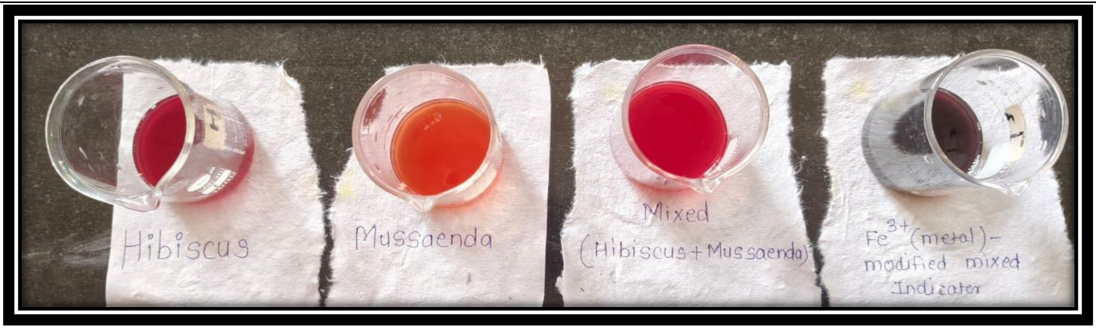
Preparation Of Indicators

- **Synthetic Indicators:** Standard solutions of phenolphthalein and methyl orange were prepared using laboratory-grade reagents.
- **Natural Indicators:** Hibiscus & Mussaenda Extract Petals were crushed and soaked in ethanol/water to extract anthocyanins. Natural indicators contain pigments that change color with pH variation, making them suitable substitutes for synthetic indicators.
- **Mixed Herbal Indicator:** Equal volumes of hibiscus and Mussaenda extracts were mixed to obtain a combined indicator.
- **Metal-Modified Indicator:** The mixed natural extract was treated with $FeCl_3$ solution to enhance color intensity and improving stability.



Hibiscus Petals Hibiscus Extract

Mussaenda Petals Mussaenda Extract



Preparation Of Solutions

- **Preparation of 0.1 M Sodium Hydroxide Solution**: A total of 4.0 g of sodium hydroxide was dissolved in distilled water and diluted to a final volume of 1000 mL.
- **Preparation of 0.1 M Hydrochloric Acid Solution**: Approximately 9.0 mL of concentrated hydrochloric acid was diluted with distilled water to make up a final volume of 1000 mL.
- **Preparation of 0.1 M Acetic acid Solution:** Approximately 6.0 mL of concentrated Acetic acid was diluted with distilled water to make up a final volume of 1000 mL.
- **Preparation of 0.1 M Ammonium Hydroxide Solution:** Approximately 7.0 mL of concentrated Ammonium Hydroxide was diluted with distilled water to make up a final volume of 1000 mL.

Titration Procedure

- A volume of 10 mL of the titrant was taken in a conical flask, and 2–3 drops of a standard indicator (phenolphthalein or methyl orange) were added.
- Titrations were carried out between two acid–base systems, namely strong acid (hydrochloric acid) versus strong base (sodium hydroxide), strong acid (hydrochloric acid) versus weak base (ammonium hydroxide) & weak acid (acetic acid) versus strong base (sodium hydroxide).
- Separately, few mL of each ethanol extract of the flower petals (**Hibiscus and Mussaenda) &** mixed extract of the flower petals (**Hibiscus and Mussaenda)** was used as a natural indicator in different conical flasks.
- Similarly, few mL of mixed extract of the flower petals (**Hibiscus and Mussaenda)** with metal modified was used as a natural indicator in different conical flasks.
- Each titration was performed in triplicate to ensure precision and reproducibility. The same titrations were repeated using standard synthetic indicators, and the results obtained using natural indicators were compared with those from synthetic indicators.
- All observations and readings were recorded systematically.

The following titrations were performed:

1. Strong acid (HCl) vs Strong base (NaOH)
2. Weak acid (CH_3COOH) vs Strong base (NaOH)
3. Strong acid (HCl) vs Weak base (NH_4OH)

Each titration was conducted using all six types of indicators.

Observations

SR. NO.	INDICATOR TYPE	BASIC MEDIUM	ACIDIC MEDIUM	ENDPOINT COLOUR	ENDPOINT VISIBILITY
1	**PHENOLPHTHALEIN (PH = 8-10)**	Pink	Colorless	Colourless	Sharp
2	**METHYL ORANGE (PH = 3.1-4.4)**	Yellow	Red	Orange	Sharp
3	**HIBISCUS (PH = 6.52)**	Green	Red	pink	Moderate
4	**MUSSAENDA (PH = 5.70)**	Greenish Yellow	Orange	Pale yellow	Moderate
5	**MIXED HERBAL (PH = 5.88)**	Greenish	Orange	pink	Improved
6	**FERRIC CHLORIDE MODIFIED MIXED HERBAL (PH = 5.68)**	Greenish	Marron	Wine red	Very sharp

Results

The comparative evaluation of indicator systems revealed clear differences in endpoint detection, color intensity, and analytical accuracy. Synthetic indicators such as Phenolphthalein and Methyl Orange consistently produced sharp and instantaneous color changes at the endpoint across all titration types. Their performance showed minimal deviation in titre values, confirming high precision and reproducibility. Herbal indicators prepared from Hibiscus and Mussaenda exhibited noticeable color changes in acidic and basic media. However, the transitions were relatively gradual, and slight variations in endpoint readings were observed. Despite this, the results remained reasonably accurate and suitable for general analytical purposes. The mixed herbal indicator demonstrated improved endpoint visibility compared to individual plant extracts. The combination of pigments resulted in deeper color contrasts, reducing uncertainty during titration. The most significant enhancement was observed in the metal-modified system using Ferric Chloride. This indicator showed a more intense and well-defined color change, with endpoint detection closely matching that of synthetic indicators. Reproducibility and consistency were also markedly improved.

INDICATOR TYPE	**TITRANT VOLUME (cm^3)**		
	HCl Vs NaOH	**CH_3COOH Vs NaOH**	**HCl Vs NH_4OH**
PHENOLPHTHALEIN (pH = 8-10)	9.8	10	5
METHYL ORANGE (pH = 3.1-4.4)	9.9	No sharp change	5.4
HIBISCUS (pH = 6.52)	9.8	9.8	5.4
MUSSAENDA (pH = 5.70)	9.9	9.8	5.4
MIXED HERBAL (pH = 5.88)	9.8	9.9	5.4
FERRIC CHLORIDE MODIFIED MIXED HERBAL (pH = 5.68)	10	9.9	5.4

Discussion

Synthetic indicators performed best because they are designed with narrow pH transition ranges, producing sharp and immediate color changes at the endpoint. Their chemical structure allows precise detection, which explains their high reproducibility and accuracy.

Natural indicators such as Hibiscus and Mussaenda based on plant pigments like anthocyanins and flavonoids. These pigments respond to pH changes gradually, leading to less distinct transitions compared to synthetic dyes. Even so, they consistently indicated pH changes and proved useful for general titration purposes where extreme precision is not required.

The mixed herbal indicator showed improved clarity of endpoints. By combining pigments from Hibiscus and Mussaenda, the system produced stronger color contrasts and a wider transition range. This synergy reduced uncertainty and enhanced the reliability of endpoint detection compared to individual extracts.

The ferric chloride-modified indicator demonstrated the greatest improvement. Interaction between Fe^{3+} ions and plant pigments intensified the color and stabilized the extract, resulting in sharper endpoints and better reproducibility. This modification made the natural indicators competitive with synthetic ones in terms of analytical performance.

From a sustainability perspective, herbal and modified indicators offer clear advantages. They are biodegradable, less toxic, and inexpensive, making them suitable for educational laboratories and environmentally conscious practices. Their effectiveness, combined with eco-friendly properties, supports their use as alternatives to conventional synthetic indicators.

Conclusion

The study confirms that synthetic indicators such as Phenolphthalein and Methyl Orange provide high accuracy and sharp endpoint detection in titrimetric analysis. However, herbal indicators derived from Hibiscus and Mussaenda demonstrate comparable effectiveness with the added benefits of environmental safety and low cost.

The use of mixed herbal indicators introduces synergistic improvements in color contrast and usability, while modification with Ferric Chloride significantly enhances their performance by producing clearer and more stable endpoints. Overall, metal-modified mixed herbal indicators emerge as a promising, sustainable alternative to conventional synthetic indicators, supporting their application in modern analytical chemistry.

Acknowledgment

The authors express their sincere gratitude to the Principal and the Department of Chemistry of T. C. T. Dr. Shree Nanasaheb Dharmadhikari Arts, Commerce & Science College, Gove–Kolad, Raigad, for providing the necessary laboratory facilities, guidance, and encouragement to carry out this research work. We are thankful to our colleagues and laboratory staff for their valuable support and technical assistance during the experimental work. We also acknowledge everyone who directly or indirectly contributed to the successful completion of this study. Finally, we express our heartfelt gratitude to our families and well-wishers for their constant encouragement, patience, and moral support throughout this research.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. Danladi, S. A., & Ruth, S. I. (2024). Harnessing Natural Plant Extracts (Hibiscus, Turmeric, and Henna) for Volumetric Analysis Indicators. ATBU Journal of Science, Technology and Education, 12(3).

– Discusses Hibiscus anthocyanins and their application as eco-friendly titration indicators.
https://www.atbufstejoste.com/index.php/joste/article/view/2168?utm_source=copilot.com

2. Tamboli, F. A., Nilawar, N. D., Jorgewar, V. Y., More, H. N., Jadhav, N. R., & Killedar, S. G. (2020). Extraction and Utilization of Hibiscus Flowers Pigments as an Indicator in Titrimetric Analysis. World Journal of Pharmacy and Pharmaceutical Sciences, 9(8), 2178-2184.

– Explores Hibiscus pigment extraction and its effectiveness compared to synthetic indicators.
https://www.researchgate.net/publication/349028581_Extraction_and_utilization_of_hibiscus_flowers_pigments_as_an_indicator_in_titrimetric_analysis

3. Chaudhari, N. M., Bendre, S. D., Deshmukh, S. V., Kumbhakarn, A. S., & Jondhale, V. S. (2024). Acid Base Indicator Paper Extracted From Rose and Hibiscus Flower. International Journal of Pharmaceutical Sciences, 2(10), 1712-1720.

   – Highlights anthocyanin-based natural indicators and their pH-dependent color changes.

https://www.ijpsjournal.com/assetsbackoffice/uploads/article/Acid+Base+Indicator+Paper+Extracted+From+Rose+And+Hibiscus+Flower+.pdf?utm_source=copilot.com

4. Gupta, M., & Singh, K. (2012). Use of Natural Dyes as Indicators in Acid-Base Titration. Journal of Natural Products and Plant Resources, 2(3), 342-344.

   – Provides comparative evaluation of natural dyes as substitutes for synthetic indicators.

5. Chengaiah, B., Rao, K. M., Kumar, K. M., Alagusundaram, M., & Chetty, C. M. (2010). Medicinal Importance of Natural Dyes: A Review. International Journal of PharmTech Research, 2(1), 144-154.– Reviews natural pigments, their chemical properties, and potential analytical applications.
6. Yustiadi F 2016 Identifikasi Pemahaman Konsep Materi Asam Basa pada Siswa Kelas XI IPA SMA Negeri 4 Malang Skripsi UM Malang Tidak dipublikasikan
7. Kousathana, Demerout M, and Tsaparlis G. 2005. Sci. Educ. 14: 173–93.
8. Undergraduate Journal of Mathematical Modeling, one + two 10(1).
9. "Acid Base Titration – Titration Curves, Equivalence Point & Indicators of Acid Base Titration" Standard 11th NCERT, Chemistry part 2, unit number 8, "Redox Reaction as the basis for titration," pg. no. 269.
10. Sing M, Sravan PK, Birendra S, Pamula BR. A comprehensive review of phytochemical and pharmacological overview on Celosia cristata for future prospective research. AJPCR. 2020;13: 21-24.
11. Butterworth C.A., 2011. ITIS - Report: Hylocereus Monacanthus (Lem.) Britton & Rose Integr. Taxon. Inf. Syst.