

Comparative Evaluation of Hydroethanolic Extracts of *Clitoria Ternatea* Flowers, *Malus Domestica* Peel, and Their Combined Extract as Potential Eco-Friendly Acid–Base Indicators

Challa Prashanthi^{1*}, Priyanka Rathod²

¹Mentor, Biology, Adani Public School, Mundra, Kutch - 370415, Gujarat, India,

²Student, Biology, Adani Public School, Mundra, Kutch - 370415, Gujarat, India

*Corresponding Authors

DOI: <https://doi.org/10.51584/IJRIAS.2026.11080067>

Received: 24 August 2026; Accepted: 29 August 2026; Published: 05 September 2026

ABSTRACT

Natural plant pigments have attracted considerable attention as environmentally friendly alternatives to synthetic acid–base indicators due to their biodegradability, low toxicity, and easy availability. The present study investigated the visual responses of hydroethanolic extracts of *Clitoria ternatea* (Butterfly Pea) flowers, *Malus domestica* (Apple) peels, and their combined extract in selected chemical solutions. Fresh flower petals and apple peels were washed with distilled water, ground using a mortar and pestle, and extracted using a hydroethanolic solvent system consisting of 70% ethanol and 30% distilled water. Three extracts—flower, fruit peel, and mixed extract—were prepared and individually introduced into sodium hydroxide (NaOH), ammonia solution (NH₃), ammonium chloride (NH₄Cl), and calcium hydroxide [Ca(OH)₂] solutions. Visible colour changes were observed in all reaction mixtures. The flower extract produced light green, sky blue, sky blue, and light pale-yellow colours in NaOH, NH₃, NH₄Cl, and Ca(OH)₂, respectively. The fruit peel extract exhibited similar colour changes with slight variations in colour intensity, while the mixed extract showed responses comparable to the flower extract. The pH of the resulting solutions was verified using universal pH paper, which produced consistent colour responses for each chemical irrespective of the extract used, indicating that the extracts did not significantly alter the measured pH of the solutions under the experimental conditions. The findings demonstrate that hydroethanolic extracts of *Clitoria ternatea* flowers and *Malus domestica* peels exhibit distinct visual responses when exposed to different chemical environments. These observations suggest that the plant extracts possess potential for use in educational demonstrations and preliminary investigations of naturally derived colour-responsive materials. Further studies employing standardized buffer solutions, quantitative colour analysis, and spectroscopic techniques are recommended to comprehensively evaluate their suitability as natural acid–base indicators.

Keywords: *Clitoria ternatea*, *Malus domestica*, natural indicator, hydroethanolic extraction, anthocyanins

INTRODUCTION

The determination of acidity and alkalinity is one of the most fundamental procedures in chemistry, biology, environmental science, food analysis, and pharmaceutical research. Acid–base indicators are substances that undergo visible colour changes in response to variations in the chemical environment and are widely used to identify the nature of chemical solutions. Conventional synthetic indicators, such as phenolphthalein, methyl orange, and bromothymol blue, have long been employed in laboratory practices due to their accuracy and reliability. However, increasing awareness of environmental sustainability and green chemistry has encouraged researchers to explore naturally occurring pigments as eco-friendly alternatives.

Natural indicators obtained from plants are biodegradable, renewable, inexpensive, and readily available. Many flowers, fruits, leaves, and vegetables contain pigments such as anthocyanins, flavonoids, betalains, and

carotenoids, which are capable of exhibiting visible colour changes under different chemical conditions. These pigments have attracted considerable scientific interest because of their potential applications in analytical chemistry, food science, environmental monitoring, and educational laboratories.

Among these plant sources, *Clitoria ternatea* L. (Butterfly Pea) is recognized as one of the richest natural sources of anthocyanin pigments known as ternatins. These water-soluble pigments are responsible for the characteristic deep blue colour of the flowers and possess remarkable colour-responsive properties under different chemical environments. Similarly, the peel of *Malus domestica* (Apple) contains anthocyanins, flavonoids, and other phenolic compounds that contribute to its pigmentation and antioxidant activity. Although both plant materials are known to contain bioactive pigments, comparative studies evaluating their visual responses under identical experimental conditions remain limited.

The extraction method plays a crucial role in obtaining pigment-rich plant extracts. In the present investigation, a hydroethanolic solvent system consisting of 70% ethanol and 30% distilled water was employed because it effectively extracts anthocyanins and other phenolic compounds while maintaining pigment stability. Fresh flowers of *Clitoria ternatea* and fresh peels of *Malus domestica* were washed with distilled water, crushed using a mortar and pestle, and extracted separately. A third extract containing a mixture of both plant materials was also prepared to investigate whether combining the two extracts produced any observable difference in colour response.

The prepared extracts were evaluated by adding a few drops to selected laboratory chemicals, namely sodium hydroxide (NaOH), ammonia solution (NH₃), ammonium chloride (NH₄Cl), and calcium hydroxide [Ca(OH)₂]. The visual colour changes of the reaction mixtures were carefully observed and recorded. To verify the nature of the resulting solutions, universal pH paper was used after the addition of the extracts. The pH paper produced consistent colour responses for each chemical regardless of the extract used, indicating that the extracts did not significantly alter the measured pH under the experimental conditions. However, the reaction mixtures themselves exhibited distinct visual colour changes, suggesting interactions between the extracted plant pigments and the chemical media.

The present study therefore aims to compare the visual responses of hydroethanolic extracts of *Clitoria ternatea* flowers, *Malus domestica* peels, and their combined extract when exposed to selected chemical solutions. By evaluating the colour behaviour of these naturally derived extracts, this investigation seeks to contribute to the growing interest in sustainable, plant-based colour-responsive materials and to provide preliminary experimental evidence for their potential use in educational demonstrations and future studies on natural acid–base indicators.

Objectives

The present study was conducted with the following objectives:

- To prepare hydroethanolic extracts of *Clitoria ternatea* flowers, *Malus domestica* peels, and their combined extract using a 70% ethanol and 30% distilled water solvent system.
- To observe and compare the colour changes produced by the three extracts when added to selected chemical solutions.
- To verify the pH of the reaction mixtures using universal pH paper.
- To compare the visual responses of the flower, fruit peel, and mixed extracts under different chemical conditions.
- To evaluate the potential of these plant extracts as eco-friendly, naturally derived colour-responsive materials for preliminary acid–base indicator studies.

MATERIALS AND METHODS

Materials

Plant materials

- Fresh flowers of *Clitoria ternatea* (Butterfly Pea)
- Fresh peels of *Malus domestica* (Apple)

Chemicals

- Sodium hydroxide (NaOH)
- Ammonia solution (NH₃)
- Ammonium chloride (NH₄Cl)
- Calcium hydroxide [Ca(OH)₂]
- Ethanol (analytical grade)
- Distilled water

Apparatus

- Mortar and pestle
- Beakers
- Measuring cylinder
- Glass rod
- Dropper
- Filter paper
- Universal pH paper
- Digital weighing balance

Preparation of plant extracts

Fresh flowers of *Clitoria ternatea* and fresh peels of *Malus domestica* were collected and thoroughly washed with distilled water to remove dust and other impurities. The cleaned plant materials were separately crushed using a mortar and pestle to obtain a fine paste.

A hydroethanolic solvent system containing 70 mL ethanol and 30 mL distilled water was added to each crushed sample to facilitate the extraction of plant pigments. The mixtures were allowed to stand undisturbed for a few minutes to ensure proper extraction of the coloured compounds.

Three different extracts were prepared:

- Flower extract (*Clitoria ternatea*)

- Fruit peel extract (*Malus domestica*)
- Mixed extract (flower + fruit peel)

The extracts were then filtered using filter paper to obtain clear solutions for further experimentation.

Figure 1: Filtration of the hydroethanolic *Clitoria ternatea* flower extract through filter paper to obtain a clear pigment solution



Preparation of chemical solutions

Solutions of sodium hydroxide (NaOH), ammonia (NH₃), ammonium chloride (NH₄Cl), and calcium hydroxide [Ca(OH)₂] were prepared in the laboratory using analytical-grade chemicals. The required mass of each chemical was calculated based on the desired molarity and accurately weighed before dissolving it in distilled water to obtain the respective solutions.

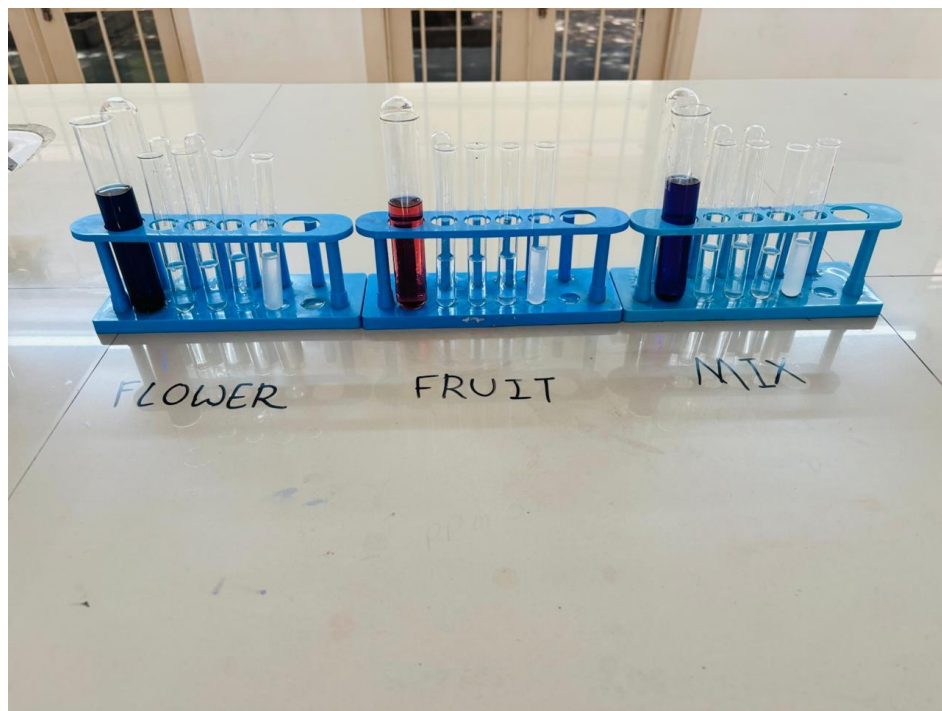
Figure 2: Prepared solutions of NaOH, NH₃, NH₄Cl, and Ca(OH)₂ with the corresponding analytical-grade reagents



Experimental procedure

Approximately equal volumes of each prepared chemical solution were transferred into separate clean test tubes. A few drops of the flower extract were added individually to NaOH, NH_3 , NH_4Cl , and $\text{Ca}(\text{OH})_2$ solutions, and the colour changes of the reaction mixtures were immediately observed and recorded. The same procedure was repeated using the fruit peel extract and the mixed extract.

Figure 3: Experimental set-up showing the flower, fruit peel, and mixed extracts alongside the chemical solutions before the addition of the extracts



Following the observation of colour changes, universal pH paper was immersed into each reaction mixture to verify the pH of the solutions. The colour developed on the pH paper was compared with the manufacturer's colour chart, and the corresponding pH values were recorded.

Observation and data recording

The following observations were recorded for each reaction mixture:

- Initial appearance of the chemical solution.
- Final colour of the reaction mixture after addition of the plant extract.
- Colour produced on the universal pH paper.
- Corresponding pH value obtained from the pH colour chart.

The colour responses of the flower extract, fruit peel extract, and mixed extract were compared to evaluate their behaviour under different chemical conditions.

RESULTS

The hydroethanolic extracts of *Clitoria ternatea* flowers, *Malus domestica* peels, and their combined extract produced visible colour changes when added to the selected chemical solutions. The reaction mixtures, which

were initially colourless, developed characteristic colours depending on the chemical and the type of extract used.

Figure 4: Colour changes developed in NaOH, NH₃, NH₄Cl, and Ca(OH)₂ after the addition of the flower, fruit peel, and mixed extracts

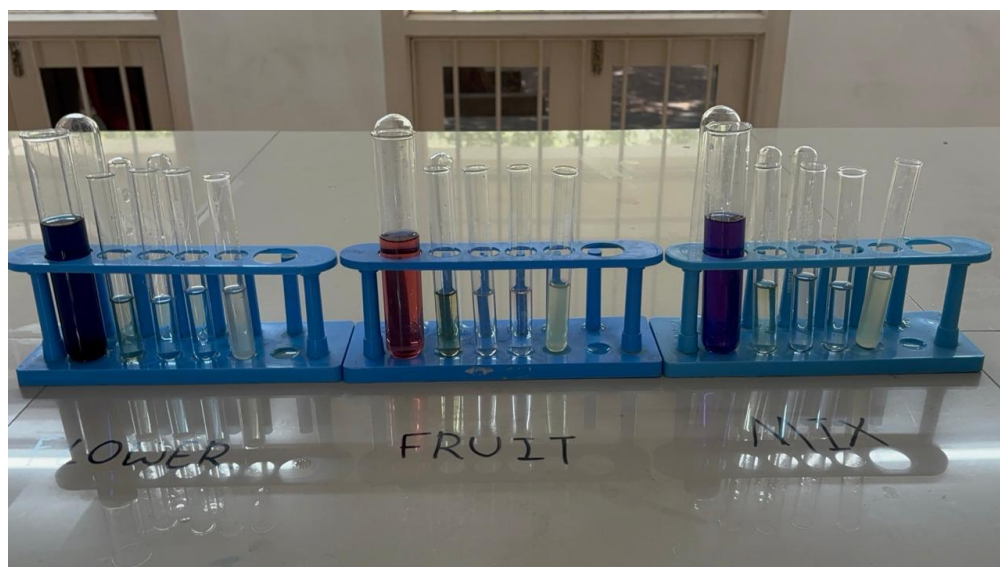


Table 1: Comparative performance of the three extracts

Parameter	Flower Extract	Fruit Peel Extract	Mixed Extract
Extraction solvent	70% Ethanol + 30% Water	70% Ethanol + 30% Water	70% Ethanol + 30% Water
Colour response in NaOH	Light Green	Slightly darker Light Green	Light Green
Colour response in NH ₃	Sky Blue	Light Sky Blue	Sky Blue
Colour response in NH ₄ Cl	Sky Blue	Light Sky Blue	Sky Blue
Colour response in Ca(OH) ₂	Light Pale Yellow	Slightly darker Light Pale Yellow	Slightly darker Light Pale Yellow
Overall response	Distinct colour change observed	Distinct colour change observed	Distinct colour change observed

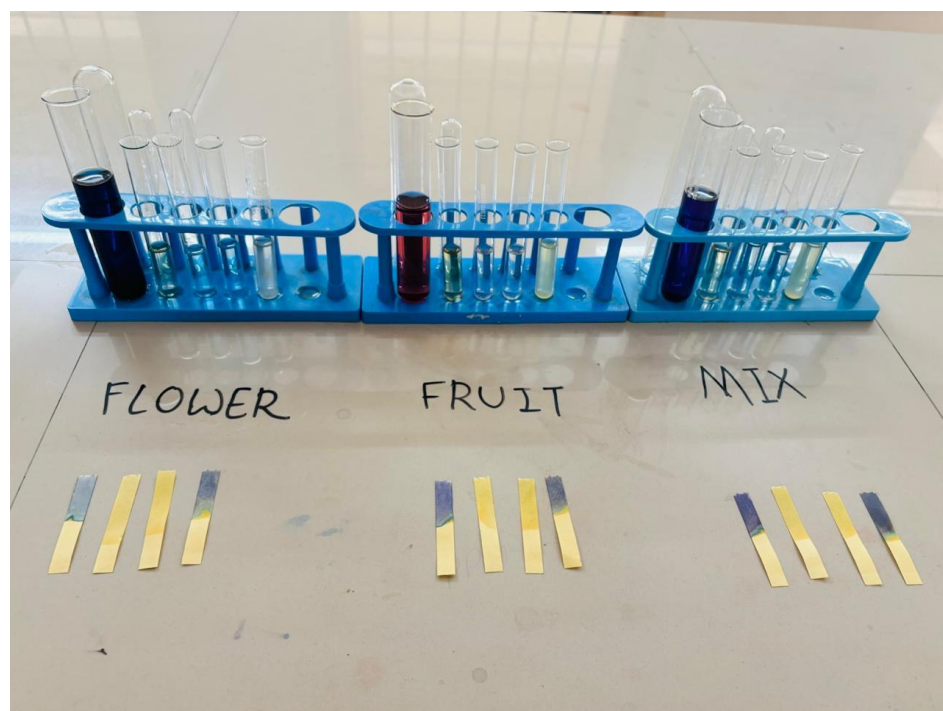
The pH of the reaction mixtures was verified using universal pH paper. The pH paper produced identical colour responses for the same chemical irrespective of the extract used, indicating consistent pH values for each test solution.

Table 2: pH verification of the reaction mixtures

Chemical Solution	Chemical Formula	Colour of Universal pH Paper	Observed pH	Nature of Solution
Sodium Hydroxide	NaOH	Dark Purple	14	Strongly Basic
Ammonia Solution	NH ₃	Yellow	10	Weakly Basic

Chemical Solution	Chemical Formula	Colour of Universal pH Paper	Observed pH	Nature of Solution
Ammonium Chloride	NH ₄ Cl	Light Orange	5	Weakly Acidic
Calcium Hydroxide	Ca(OH) ₂	Purple	13	Strongly Basic

Figure 5: Reaction mixtures of the three extracts together with the corresponding universal pH paper strips used for pH verification



DISCUSSION

The present study evaluated the visual responses of hydroethanolic extracts of *Clitoria ternatea* flowers, *Malus domestica* peels, and their combined extract when introduced into selected chemical solutions. All three extracts produced distinct colour changes, demonstrating that the plant pigments interact with different chemical environments. The observed colour variations are primarily attributed to naturally occurring anthocyanins and other phenolic pigments present in the flower and apple peel extracts. These pigments undergo structural changes under different chemical conditions, resulting in visible colour responses. Minor differences in colour intensity between the flower, fruit peel, and mixed extracts may be due to differences in pigment concentration and composition.

Universal pH paper was used to verify the pH of the reaction mixtures. The pH paper produced identical colour responses for each chemical regardless of the extract used, indicating that the addition of a few drops of plant extract did not produce a measurable change in the pH of the prepared solutions. Thus, the observed colour changes were associated with the interaction of the extracts with the chemical media rather than with changes in the pH values of the solutions.

Overall, the findings indicate that hydroethanolic extracts of *Clitoria ternatea* flowers and *Malus domestica* peels exhibit noticeable visual responses in different chemical environments and show potential as naturally derived, eco-friendly colour-responsive materials. Further investigations using standard buffer solutions, digital pH measurements, and spectrophotometric analysis would provide a more comprehensive evaluation of their applicability as natural acid–base indicators.

CONCLUSION

This study successfully prepared hydroethanolic extracts of *Clitoria ternatea* flowers, *Malus domestica* peels, and their combined extract using a 70% ethanol–30% distilled water solvent system. All three extracts produced observable colour changes when introduced into the selected chemical solutions, indicating their ability to respond visually to different chemical environments.

The universal pH paper confirmed the pH of the tested solutions and produced consistent readings irrespective of the extract used. Among the three extracts, only minor variations in colour intensity were observed, while the overall colour responses remained comparable.

The study demonstrates that the selected plant extracts can serve as naturally derived colour-responsive materials and may have potential for educational demonstrations and preliminary investigations of natural acid–base indicators. The findings also highlight the value of plant-based pigments as sustainable and environmentally friendly alternatives for simple laboratory applications.

Future Scope

- Evaluate the extracts using standard buffer solutions over a wider pH range to determine their complete colour transition profile.
- Compare the performance of the plant extracts with conventional synthetic indicators such as phenolphthalein and methyl orange.
- Use digital pH meters and spectrophotometric analysis to obtain more precise and quantitative measurements of colour changes.
- Investigate the stability and shelf life of the extracts under different storage conditions.
- Explore the preparation of natural indicator strips or eco-friendly pH test papers using these plant extracts for educational and laboratory applications.

These studies would provide a more comprehensive understanding of the indicator properties of the selected plant extracts and support their potential use as sustainable alternatives to synthetic indicators.

Declarations

Ethical approval

This study did not involve human participants or animal subjects. Therefore, ethical approval was not required.

Conflict of interest

The author declares that there is no conflict of interest.

Data availability

All data generated and analysed during this study are included within this published article.

REFERENCES

1. Abdullah, N. A., Chong, G. H., Azman, E. M., & Zainal Abedin, N. H. (2025). Evaluation of butterfly pea (*Clitoria ternatea*) extract with different ethanol–water solutions for potential natural colorant indicator. *Food Science and Engineering*, 6(2), 263–275. <https://doi.org/10.37256/fse.6220256856>

2. Gonçalves, G. C. P., Rosas, A. L. G., de Sousa, R. C., Vieira, T. R. R., de Albuquerque Sousa, T. C., Ramires, T., da Silveira, T. F. F., Barros, L., da Silva, W. P., Dias, Á. R. G., Zavareze, E. da R., & Meinhart, A. D. (2024). A green method for anthocyanin extraction from *Clitoria ternatea* flowers cultivated in southern Brazil: Characterization, in vivo toxicity, and biological activity. *Food Chemistry*, 435, 137575. <https://doi.org/10.1016/j.foodchem.2023.137575>
3. Handayani, L., Aprilia, S., Arahman, N., & Bilad, M. R. (2024). Identification of the anthocyanin profile from butterfly pea (*Clitoria ternatea* L.) flowers under varying extraction conditions: Evaluating its potential as a natural blue food colorant and its application as a colorimetric indicator. *South African Journal of Chemical Engineering*, 49, 151–161. <https://doi.org/10.1016/j.sajce.2024.04.008>
4. Harborne, J. B. (1998). *Phytochemical methods: A guide to modern techniques of plant analysis* (3rd ed.). Chapman & Hall.
5. Jeyaraj, E. J., Lim, Y. Y., & Choo, W. S. (2021). Effect of organic solvents and water extraction on the phytochemical profile and antioxidant activity of *Clitoria ternatea* flowers. *ACS Food Science & Technology*, 1(9), 1567–1577. <https://doi.org/10.1021/acsfoodscitech.1c00168>
6. National Council of Educational Research and Training. (2022). *Chemistry: Textbook for class XI (Part I)*. NCERT.
7. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2014). *Fundamentals of analytical chemistry* (9th ed.). Brooks/Cole, Cengage Learning.
8. Vidana Gamage, G. C., Lim, Y. Y., & Choo, W. S. (2021). Anthocyanins from *Clitoria ternatea* flower: Biosynthesis, extraction, stability, antioxidant activity, and applications. *Frontiers in Plant Science*, 12, 792303. <https://doi.org/10.3389/fpls.2021.792303>