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Comparative study of natural and synthetic indicators in acid-base titration supported by UV-Visible spectral analysis

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Abstract- ***Objective:*** *To assess the effectiveness of natural indicators derived from* Celosia cristata *flowers and red dragon fruit peel in acid–base titrations and to compare their performance with commonly used synthetic indicators in terms of accuracy, sensitivity, and color transition.*

Methodology: *Petals of* Celosia cristata *and peels of red dragon fruit were collected and ground using a mortar and pestle. The crushed materials were subjected to maceration for 24 hours using ethanol and acetone as solvents. The extracts were then filtered using Whatman filter paper. The obtained filtrates were utilized as natural indicators for acid–base titrations and stored in amber-colored bottles to prevent degradation.*

Conclusion: *The natural indicators exhibited titration end points comparable to those of synthetic indicators. UV–visible spectroscopic analysis confirmed their pH-responsive behavior. Hence, these natural extracts can serve as effective, eco-friendly alternatives to conventional synthetic indicators in acid–base titrations.*

Keywords: ***Celosia cristata*, red dragon fruit peel, pH measurement, acid–base titration, UV–visible spectroscopy.**

Introduction

Acid–base chemistry is a core area of chemistry that provides the basis for understanding related topics such as acid–base titrations, buffer solutions, and salt hydrolysis. The concept of acids and bases requires students to grasp different levels of representation, including observable (macroscopic), particle-level (microscopic), and symbolic interpretations. Acid–base titration is a quantitative analytical method used to measure the concentration of an acidic or basic solution by reacting it with a standard solution of known strength. It can also be described as a laboratory technique designed to obtain information about solutions containing acidic or basic substances. A wide range of compounds, including both organic and inorganic substances, can be analysed through titration based on their acidic or basic nature. During the titration process, an acid reacts with a base or vice versa, and the completion of the reaction is detected using a suitable indicator. Acid–base titrations may involve combinations of strong and weak acids and bases and are commonly applied to determine the concentration of unknown solutions and to assess the relative strength of acids or bases. Different types of indicators are used in acid–base titrations, with commonly employed laboratory indicators including methyl red, methyl orange, phenolphthalein, phenol red, methyl yellow, pentamethoxy red, bromophenol blue, and thymol blue. Among these, phenolphthalein and methyl orange are most widely used. Indicators are substances that undergo a visible color change within a specific pH range. Most indicators are organic compounds, and phenolphthalein is often preferred due to its sharp and easily noticeable color transition, especially in strong acid–strong base titrations. Methyl orange is generally selected for strong acid–weak base titrations because it changes color rapidly near the equivalence point. In weak acid–weak base titrations, neither phenolphthalein nor methyl orange is appropriate, as the pH change near the equivalence point is not sufficiently steep; therefore, indicators are usually not used. For titrations involving a weak acid and a strong base, phenolphthalein is commonly chosen because it provides a distinct color change at the equivalence point.

Because acid–base titrations are based on neutralization reactions between acids and bases, they are also known as neutralization titrations. Indicators are colored pigments or dyes that can be obtained from various natural sources such as plants, fungi, and algae. Nearly all red, blue, or purple-colored fruits and flowers contain a group of natural pigments called anthocyanins, which exhibit pH-dependent colour changes.

PLANT PROFILE:

Fig. no.: 01 CELOSIA CRISTATA

TAXONOMY CLASSIFICATION:

- Kingdom: Plantae
- Class: Magnoliopsida
- Order: Caryophyllales
- Family: Amaranthaceae
- Genus: Celosia
- Species: Cristata
- Synonyms: Celosia argentea var. cristata

PLANT PROFILE:

Fig no.: 02 RED DRAGON FRUIT

TAXONOMY CLASSIFICATION:

- Domain: Eukaryota
- Kingdom: Plantae
- Phylum: Tracheophyta
- Subphylum: Spermatophytina
- Class: Magnoliopsida
- Order: Caryophyllales
- Family: Cactaceae
- Genus: Hylocereus
- Species: Hylocereus polyrhizus
- Synonym: Hylocereus monacanthus, Selenicereus monacanthus

METHODOLOGY:

Materials: The materials are Celosia cristata flowers, red dragon fruit peels, distilled water, ethanol, acetone, sodium hydroxide, concentrated hydrochloric acid, phenolphthalein, and methyl orange.

Apparatus: The apparatus consists of a mortar and pestle, weighing balance, beakers, conical flask, burette, pipette, retort stand with clamp, white tile, wash bottle, spatula, stirrer, and filter paper (Whatman 40).

Collection of plants: Celosia cristata flowers and red dragon fruit peels were collected from the nearby villages around Dharmapuri district, Tamil Nadu, India.

Extraction Procedure

Preparation of Acetone and Ethanol Extracts:

The flower petals and fruit peels were thoroughly rinsed with distilled water and cut into small pieces. The plant materials were then ground using a mortar and pestle to obtain a fine paste. The crushed samples were transferred into separate 250 mL iodine flasks containing 50 mL of absolute ethanol and acetone, respectively. The flasks were stored in a dark cupboard for 24 hours to allow complete maceration and efficient extraction of pigments. After the extraction period, the mixtures were filtered using Whatman filter paper, and the clear filtrates were collected. These extracts were used as natural indicators in titration experiments, while phenolphthalein and methyl orange served as reference synthetic indicators.

Determination of pH Range

Step 1: Calibration of the pH Meter

The pH meter was calibrated using standard buffer solutions of known pH values to ensure accurate and reliable measurements.

Step 2: Preparation of Natural Indicator Solution

Plant extracts were prepared using ethanol and acetone as solvents through the maceration method involving flower petals and fruit peels.

Step 3: Measurement of Ph

The pH of each prepared natural indicator solution was measured carefully using the calibrated pH meter.

Step 4: Identification of pH Range

The approximate pH range over which each natural indicator exhibited visible color changes was determined by observing its behavior in acidic and basic media.

Preparation of Solutions

Preparation of 0.1 M Sodium Hydroxide Solution:

A total of 4.2 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 8.5 mL of concentrated hydrochloric acid was diluted with distilled water to make up a final volume of 1000 mL.

Titration Procedure

A volume of 20 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). Separately, 1 mL of each ethanol and acetone extract of the flower petals and fruit peels 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.

Ultraviolet (UV) Spectroscopic Analysis

Procedure:

UV–visible spectroscopic analysis was carried out using a Genesys 180 UV–Vis spectrophotometer. Prior to analysis, the cuvettes were thoroughly cleaned with distilled water. The instrument was calibrated using ethanol and acetone as blank solvents at a wavelength of 400 nm. For analysis, 1 mL of each plant extract was diluted with 5 mL of the respective solvent. Approximately 5 mL of the diluted extract was transferred into the cuvette, and absorbance measurements were recorded in the visible region ranging from 200 to 400 nm. The wavelength of maximum absorption (λmax) for each extract was determined from the obtained absorption spectra.

Results:

PH range determination:

Ethanol extract: Celosia cristata flower extract = 6.60 and red dragon fruit peel extract = 5.87.
Acetone extract: Celosia cristata flower extract = 6.01 and red dragon fruit peel extract = 5.84.

Table no.: 01 Titration process:

Indicators	Titrant volume	Colour change
Phenolphthalein	21	Colourless to pink
Methyl orange	25.2	Colourless to yellow
Ethanol extracts celosia cristata flower	22.6	Colourless to yellow
Ethanol extracts red dragon fruit peel	23.4	Colourless to yellow
Acetone extracts celosia cristata flower	24	Colourless to yellow
Acetone extracts red dragon fruit peel	25.4	Colourless to yellow

UV Spectrum analysis:

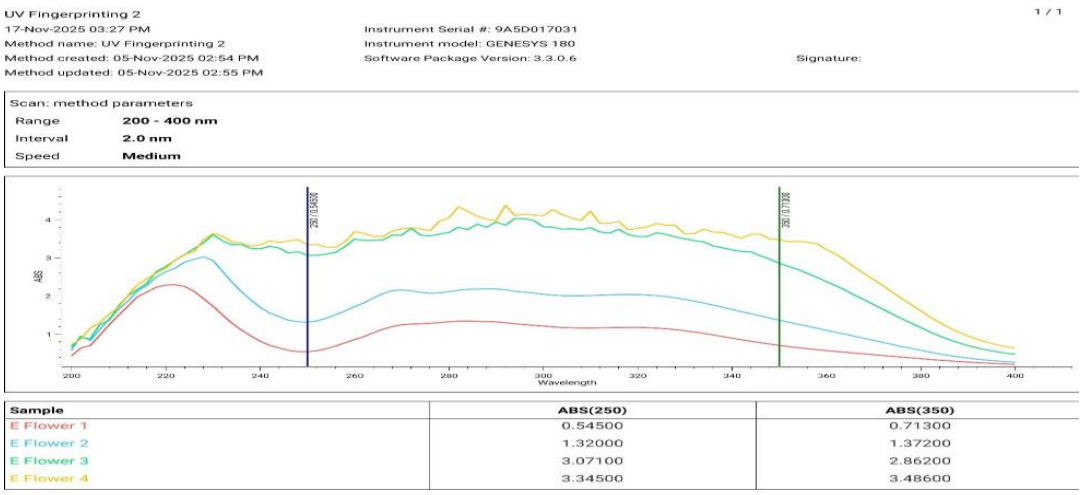
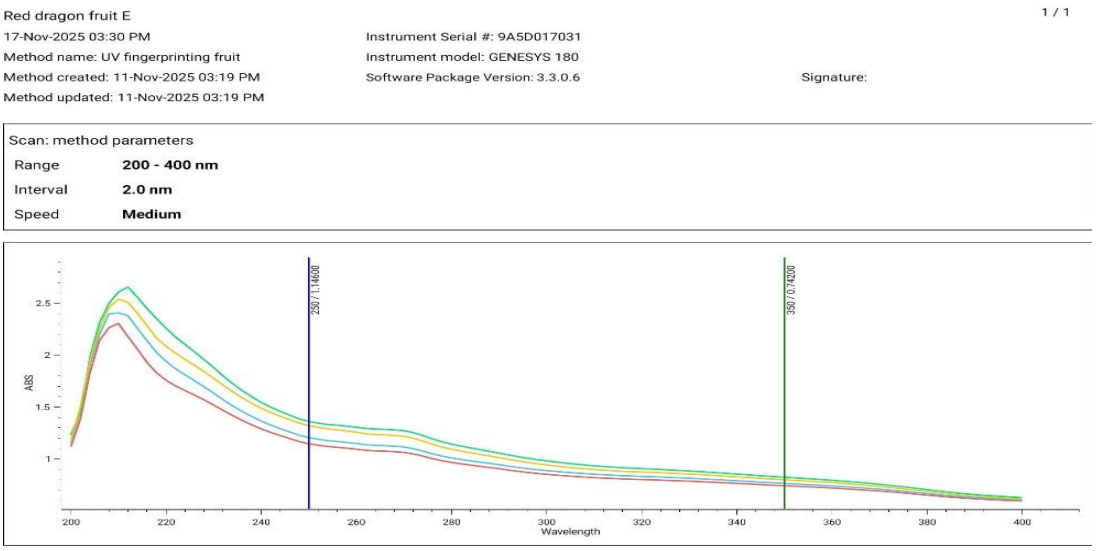
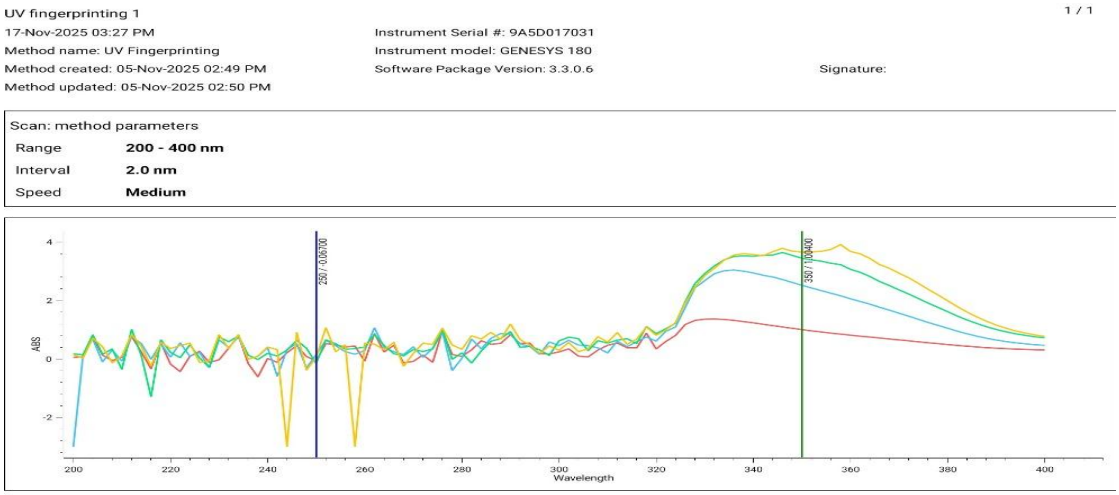


Fig. no: 03 Ethanol Extract of Celosia Cristata Flower



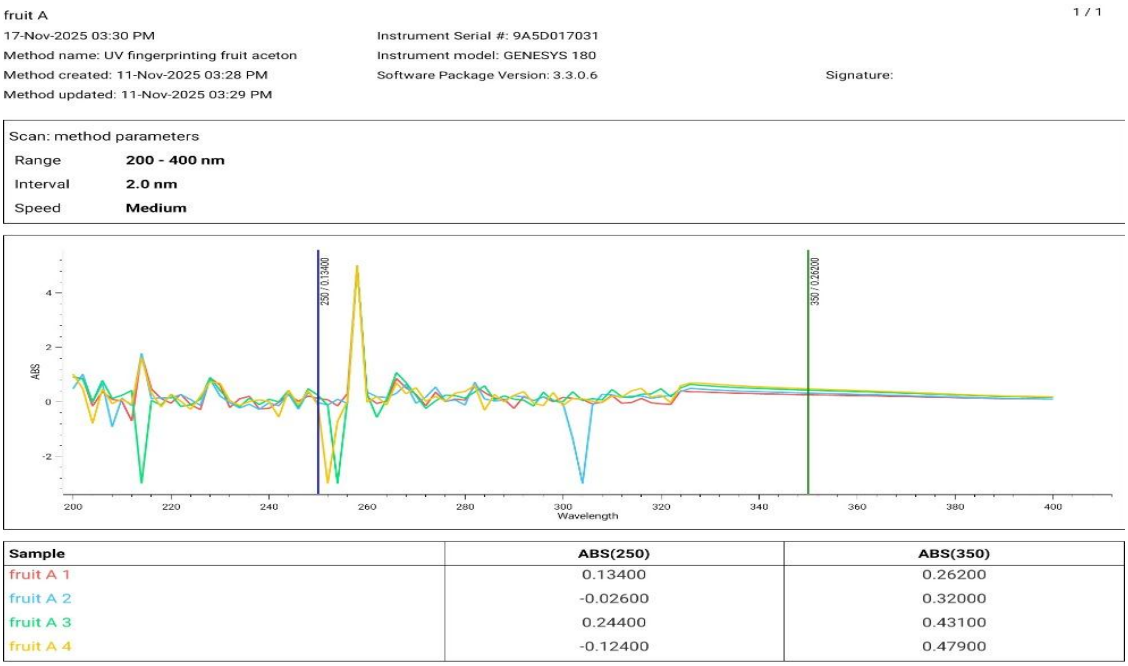
Sample	ABS(250)	ABS(350)
fruit E 1	1.14600	0.74200
fruit E 2	1.20500	0.76400
fruit E 3	1.36100	0.82300
fruit E 4	1.32000	0.79900

Fig. no: 04 Ethanol Extract of Red Dragon Fruit Peel



Sample	ABS(250)	ABS(350)
A flower 1	-0.06700	1.00400
A flower 2	0.14900	2.51900
A flower 3	-0.15200	3.44500
A flower 4	0.05700	3.65300

Fig. no: 05 Acetone Extract of Celosia Cristata Flower



Sample	ABS(250)	ABS(350)
fruit A 1	0.13400	0.26200
fruit A 2	-0.02600	0.32000
fruit A 3	0.24400	0.43100
fruit A 4	-0.12400	0.47900

Fig. no: 06 Acetone Extract of Red Dragon Fruit Peel

Conclusion

The findings of this study indicate that extracts obtained from *Celosia cristata* flowers and red dragon fruit peels are effective as natural indicators in acid–base titrations. Both extracts displayed distinct and well-defined color transitions over a broad pH range, and UV–visible spectroscopic analysis confirmed the presence of stable pigment molecules responsible for these color changes.

The titration end points achieved using the natural indicators closely matched those obtained with conventional synthetic indicators, demonstrating comparable accuracy, consistency, and reproducibility. These results suggest that plant-derived indicators offer a reliable, economical, environmentally friendly, and non-toxic alternative to commonly used synthetic indicators in routine titration procedures.

In conclusion, *Celosia cristata* flower and red dragon fruit peel extracts show strong potential for application as natural acid–base indicators in analytical chemistry.

References:

1. Yustiadi F 2016 Identifikasi Pemahaman Konsep Materi Asam Basa pada Siswa Kelas XI IPA SMA Negeri 4 Malang Skripsi UM Malang Tidak dipublikasikan
2. Kousathana, Demerout M, and Tsaparlis G. 2005. Sci. Educ. 14: 173–93.
3. Undergraduate Journal of Mathematical Modeling, one + two 10(1).
4. “Acid Base Titration – Titration Curves, Equivalence Point & Indicators of Acid Base Titration”
5. Standard 11th NCERT, Chemistry part 2, unit number 8, “Redox Reaction as the basis for titration,” pg. no. 269.
6. 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.
7. Butterworth C.A., 2011. ITIS - Report: Hylocereus Monacanthus (Lem.) Britton & Rose Integr. Taxon. Inf. Syst.