International Journal of Advance and Innovative Research
Volume 12, Issue 2: April - June 2025
ISSN 2394 - 7780

PEELS FOR THE PLANET: ECO-FRIENDLY INDICATORS FOR SUSTAINABLE SOLUTIONS

Ankita Gupta
Assistant Professor, Department of Chemistry, SET's Rajiv Gandhi College of Arts, Commerce & Science, Vashi, Navi Mumbai, Maharashtra-400703

INTRODUCTION

The word indicator has been derived from the Late Latin word 'indico' which mean "point out" or "to indicate something". At early days, to identify the given compound one has to taste the compound whether its acidic or basic in nature if the taste is bitter then it was consider as basic in nature or if it taste as sour then it is consider as acidic in nature[6]. But there are some of the compound which might be dangerous to health on tasting, so to avoid this scientists conducted theories, experiment & concluded that one can identify the compound nature using indicator[2].

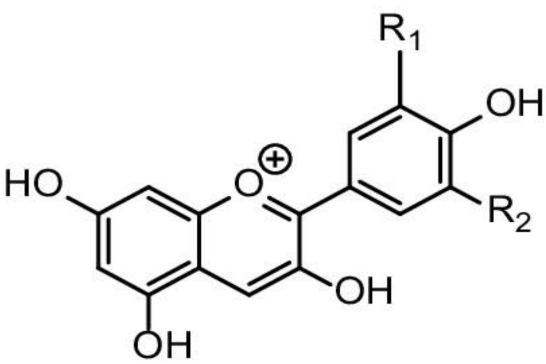
An derived its definition as "it's a substances which shows characteristic property mainly in terms of color, odour, etc. depending upon the medium provided whether its acidic or basic. Basically indicator is used to measure the pH qualitatively, where it designate the pH of the solution.

Plus it also helps to determine the strength of acid or base in moles. Mostly indicators are used in Acid-Base titration, to conclude its end point respectively[5]. Generally indicator are of two types i.e. Natural indicator and other is synthetic indicator or man-made indicator prepared at laboratory. Litmus paper, turmeric paper are the example of the natural indicator while phenolphthalein, methyl orange are the synthetic indicator[5]. Since the synthetic indicator are prepared in industries for e.g.: phenolphthalein is synthesized by the condensation of phthalate anhydride and phenol where the starting material used is toxic and harmful for the environment and as well as for the human health which may cause irritation & lung cells injuries[2].

By keeping this in mind, Green chemistry plays an important role over here. Because in order to protect environment and human health, from these commercially synthesized chemicals, one can extract or use the chemical derived from the natural sources such as plants, peels of vegetable, leaves, flower, etc. As they are cheaper, easier to extract and its ecofriendly to nature[8].

As we know that the vegetable & fruits are consider as mandatory diet food from all over the world, especially in India. So the waste generated from leftover vegetable and fruits such as peels or culls in large quantities are dumped into water bodies or in the soil every day, which may generates harmful microbes as it contain high ratio of carbon/nitrogen as well as moisture[1]. So to overcome from these problem we can utilize this waste into a productive way. And this peels can be used for the extraction of indicator as it contain color and pigment which is responsible due to the presence of anthocyanin's[3]. Anthocyanin are highly pigmented, responsible for the color change in the solution with a change in pH. Dark-colored vegetable and fruits that contain flavone or anthocyanin can be used as an indicator. Mostly red, purple, and pink peels vegetable and fruits extract is used as an indicator[9]. Anthocyanins possess properties such as ant diabetic, anticancer, and anti-inflammatory which are also used in cardiovascular diseases. So it is also beneficial in the medical field. Due to these reasons, it gained more attention and became more attractive for the researchers[9].

Structure of anthocyanin:



Researchers have studied and reported the effectiveness of natural indicators used for acid-base titration[1]. Some vegetables peel, like onion peel, sweet potatoes, etc., work as indicators that change the color of an acid or base solution just like phenolphthalein and methyl orange indicator. The pigmentation of the indicator can be investigated by UV-Vis spectroscopy[15].

Benefits for using organic indicators from using peels generally waste of vegetables & fruits:

- It will provide economic opportunity of converting food waste into valuable resources. This can create new industries, jobs, and revenue streams focused on sustainable practices, waste management, and circular economies.
- Governments can support the use of vegetable and fruit peel-based indicators by incentivizing research, offering grants for sustainability initiatives, and integrating these technologies into national environmental monitoring programs.
- To make aware of the potential of using eco-friendly indicators to educate the public about the importance of sustainability. Schools, universities, and local communities could be involved in projects that utilize these organic indicators for hands-on learning about environmental stewardship.
- Basically it have economical & environmental benefits for the future of upcoming society whether it may at school or colleges level while in the case of industrial application & Waste Management Programs.

So it well define the Sustainability word by redefining the indicator with the perspective of business, technology & the better use in the society.

LITERATURE REVIEW:

For acid-base titrations, phenolphthalein and methyl orange are the synthetic indicators that are most frequently used. However, there are many drawbacks that make using natural substances as acid-base indicators necessary, including availability issues, pollution of the environment, and increased expense. The purpose of this experiment was to identify environmentally acceptable natural indicators using some fruit and vegetable waste. As demonstrated by acid-base titrimetric at room temperature, the peels' potential is quite promising. Certain fruits and vegetables' peels were removed, divided, and cleansed. At the equivalency point, these indicators—which were utilised in acid-base titrations—show dramatic colour shifts. When natural pigments were used as appropriate acid-base indicators, the outcome proved to be satisfactory. These inexpensive, straightforward, accurate, helpful, and environmentally friendly natural indicators have been found[1]

The goal of this research is to create universal indicators from organic waste products. This research and development (R&D) uses an altered version of the ADDIE paradigm. The designed universal indicator was applied to the Senior High School class XI MIPA in Bantul, Yogyakarta. Tests, questionnaires, observations, interviews, and product validation sheets are the methods utilized to collect data. The findings demonstrated that the universal indicator has an 11-day storage life and can detect pH values between 0 and 14. Based on validators' evaluations, the generated product has met valid criteria, achieving an average percentage of 94.20%. With an average percentage of 95.00% based on students' science skills and 75.00% based on student learning outcomes and practical criteria, the generated product has met the successful requirements [2]

Petrochemical-derived synthetic pigments have found widespread application in a variety of food products. Unfortunately, the negative health impacts of these pigments have forced scientists to search for safer, more natural, and environmentally friendly alternatives. In this sense, it is imperative to fully utilise the potential of agri-food wastes, which is primarily achieved by utilizing environmentally friendly extraction and processing techniques. Because of their many applications, pigments have seen a tremendous increase in market size recently. Therefore, the manufacture of pigments from renewable bio resources must be done sustainably. The industrial needs of natural pigment manufacturing can be satisfied by valorizing vegetal wastes (fruits and vegetables) and their byproducts (such as peels, seeds, or pomace) for possible use in food, medicine, and indicator.[3]

Because synthetic dye disposal has a negative impact on the environment and living systems, it is now a matter of concern. As a result, attempts are already being made to switch out these dangerous colours with natural dyes derived from plants. The purpose of our work was to extract natural dye from Aster chinensis discarded flowers and investigate its potential use as a pH indicator in acid-base titrations. The petals of discarded aster flowers with shades of pale and dark pink were used. Numerous acid-base titrations, including strong base-strong acid, strong base-weak acid, weak acid-strong base, weak base-strong acid, and strong acid-weak base, were used to examine their suitability as natural indicators. Additionally, same titrations were carried out independently using methyl red and phenolphthalein, two common synthetic indicators[4]

This article discusses the problem- and project-based learning (PPBL) program at Arizona State University's School of Sustainability (SOS) and its institutional context. The study aims to provide experience-based guidance for similar initiatives in sustainability programs worldwide. Data was collected through literature reviews, observations, interviews, student evaluations, and faculty surveys. The review demonstrates the successful inauguration of a PPBL program in sustainability at a major US university. However, the key challenge for this program is maintaining institutional momentum and making advances after the initial takeoff. SOS is working to address this by developing greater program cohesion, synthesizing past products and learning, monitoring and evaluating impacts, and developing PPBL training programs for faculty and graduate students. The experiences and findings can help other programs articulate the benefits of a PPBL initiative, anticipate implementation challenges, and support their own initiatives through adequate institutional structures. Successful PPBL programs require top-down commitments from the administration and bottom-up drive from interested faculty and students.[5]

The study examines the acid-base indicator properties of Rose, Allamanda, and Hibiscus flowers. The extracts show sharp contrast between acid and base colors, with pH values similar to synthetic indicators. The results suggest natural indicators could be an excellent replacement for synthetic indicators due to their affordability, availability, simplicity, non-toxic nature, user-friendliness, and environmental friendliness.[9]

METHODOLOGY:

Materials: Distilled water, ethanol, Fresh fruits and vegetables (beetroot, onion, carrot, banana and orange) were purchased from the local market of Turbhe, Navi Mumbai, India for the extraction from the peel.

Vegetable peel such as beetroot, onion, carrot, purple cabbage, spinach, sweet potato, fenugreek, carrot, etc. and fruits peels waste such as apple, orange, watermelon, banana, etc. were collected for extraction purpose**,** some of them are shown below.

Fig.(a)

Fig.(b)

Fig.(c)

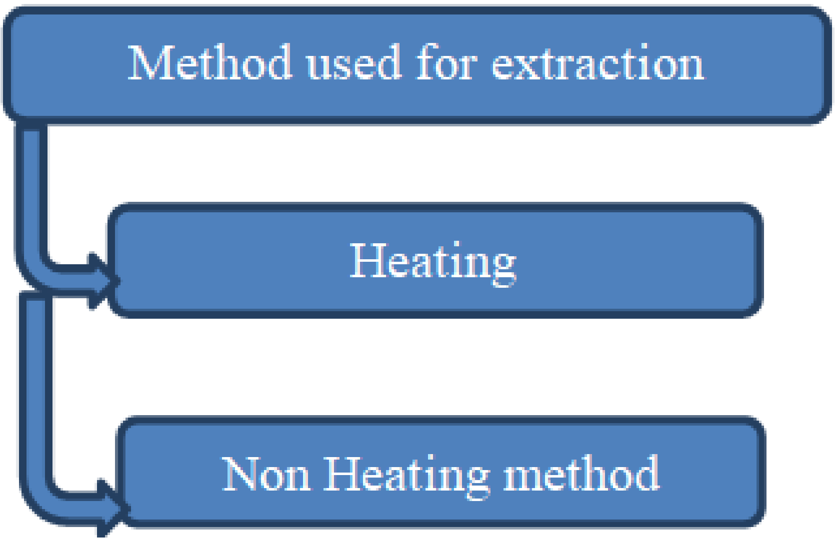
Fig.(d)

Where the fig.(a) shows the purple cabbage, fig.(b) shows sweet potato, fig.(c) shows apple peel while the fig.(d) represents the onion peel, respectively.

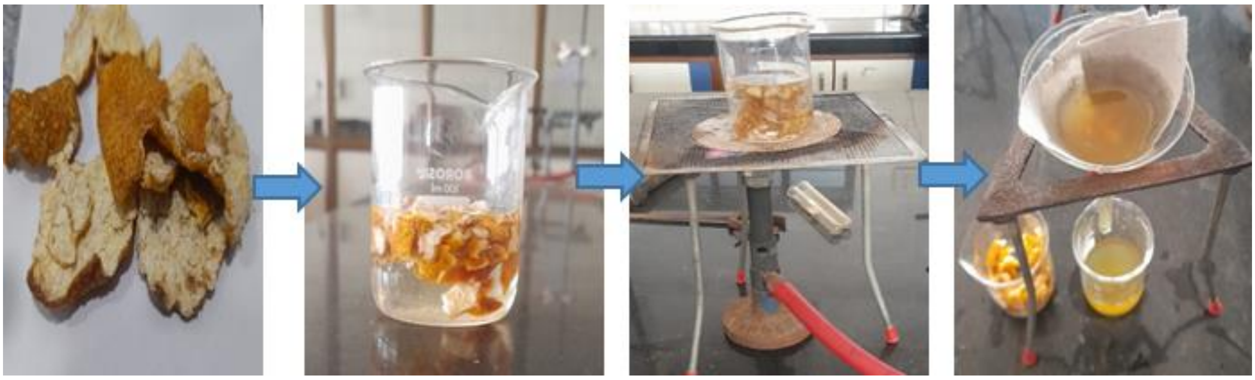
Reagents: Hydrochloric acid, Sodium hydroxide, Succinic acid, etc.

Apparatus: 250 cm^3 conical flask, 250 cm^3 beaker, 100 cm^3 beaker, burette, pipette, funnel, etc.

Methods:



Heating method: Exactly 5 grams of each sample of vegetable and fruit peels waste was weighed into a paper and it was placed in the conical flask. Then with the help of the measuring cylinder 50 cm^3 of distilled water was transfer into it and allowed to boil until it become half of its volume. Once its volume get reduce, it was kept for cooling at normal room temperature. And after that, with the help of the separating funnel the unwanted solid waste was separated and then colored solution was obtain, below fig.(e) demonstrate the heating process used for the extraction of indicator.



Fig(e) It represent the extraction of indicator through the heating process

Maceration method via. Non-heating method: The maceration method was carried out by soaking the all the natural material wastes with ethanol in a ratio of 1:5. As this ratio provide the good contact between the solvent and the solid so that the distribution of the solvent to the solid is evenly distributed. For these process, exactly 5 grams of sample of each vegetable and fruits peel waste was weighed and transferred into separate beakers; and then 25ml. of ethanol was added into each sample and left overnight for 24 hrs. On the following day, they were decanted into clean beakers. And then transferred into 25 ml of dark amber lite standard flask. And it can be well understand as shown below in fig.(f)

Fig.(f) It represent the extraction of indicator through the maceration method

Characterization of Extract: The extracts were characterized with the use of UV/Visible spectroscopy to determine the wavelength of maximum absorption.

Reaction of the Extracts with Acids and Bases: Samples of the extract obtained were added to different acids and bases to test if there will be any colour change. The acids used for these were HCl and ($C_4H_6O_4$), while the bases used were NaOH of different strength.

Acid-Base Titration with Extract as Indicator: Titrations were carried out using 0.2 M NaOH and 0.2M HCl for strong acid-strong base titration. 0.1M solution of ($C_4H_6O_4$) and 0.1M NaOH were used for weak acid strong base titration.

The accuracy of the end point for all experimental samples and trials was repeated three (3) times to check the precision.

Ultraviolet (UV) Spectroscopy and reliability: The Labnidia3000 spectrophotometer was used; the cell to be used for the UV/Visible spectroscopy was washed thoroughly with distilled water. Distilled water was used to calibrate the instrument at the wavelength of 400nm. 3 mL of the extract was measured and placed in the cell. The absorbance of the extract was determined within the visible region (i .e.400- 700 nm) and the wavelength of maximum absorption (λ_{max}) of each extract was extrapolated from the graph.

 ISSN 2394 - 7780

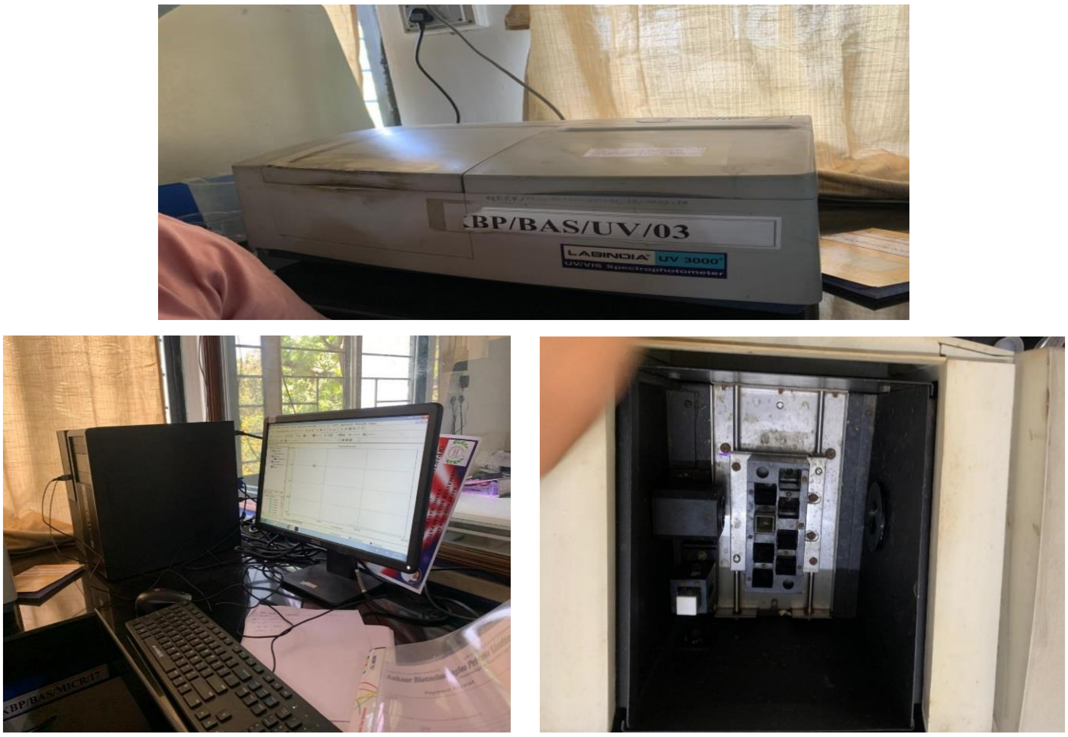


Fig.(g) UV/Vis Spectrophotometer

RESULT AND DISCUSSION

End point results in titrimetric analysis using synthetic and natural indicators

Indicator extracted via. Distilled water

Titrant vs. Titrand	Indicator	End point	Mean titration reading ± SD
NaOH vs HCl	Methyl orange	Pink to yellow	10±3
	Purple cabbage	Pink to greenish	10±2
	Onion peel	Orange to greenish	10±1
	Carrot peel	Colorless to yellow	11±1
	Sweet Potato peel	Pink to greenish	10±1
	Apple peel	Pink to colorless	10±2
	Beetroot peel	Dark pink to orange	10±5
	Watermelon peel	Colorless to yellow	13±5
	Pomegranate peel	Orange to brown	10±5
	Spinach waste	Yellowish color	
	Fenugreek waste	Yellowish color	
	Orange peel	Colorless to green	12±5
Succinic acid vs NaOH	Phenolphthalein	Colourless to pink	10±1
	Methyl orange	Pink to yellow	5±2
	Purple cabbage	Purple to blue	10±5
	Onion peel	Orange to greenish	10±0
	Carrot peel	Colorless to yellow	11±1
	Sweet Potato peel	Pink to greenish	10±2
	Apple peel	Pink to greenish	10±5
	Beetroot peel	Reddish to yellowish	10±7
	Watermelon peel	Yellowish color	
	Pomegranate peel	Orange to yellow	10±2
	Spinach waste	Yellowish color	
	Fenugreek waste	Yellowish color	
	Orange peel	Colorless to light green	10±5

ISSN 2394 - 7780

End point observed for Acid-Base titration:

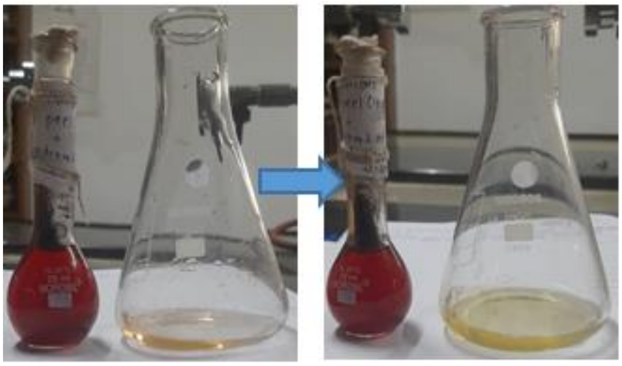


Fig.(h) Onion peel extract indictor

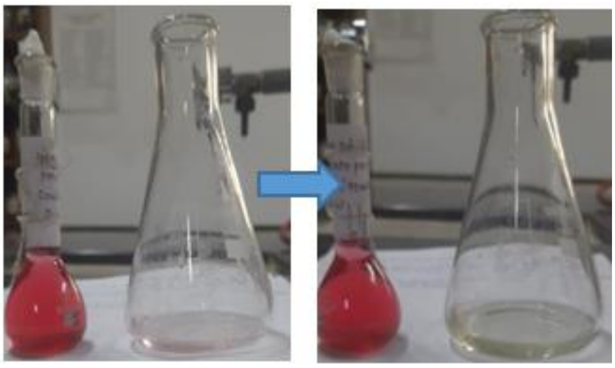


Fig.(i) Sweet potato extract indicator

Fig.(j) Pomogranate peel extract indicator

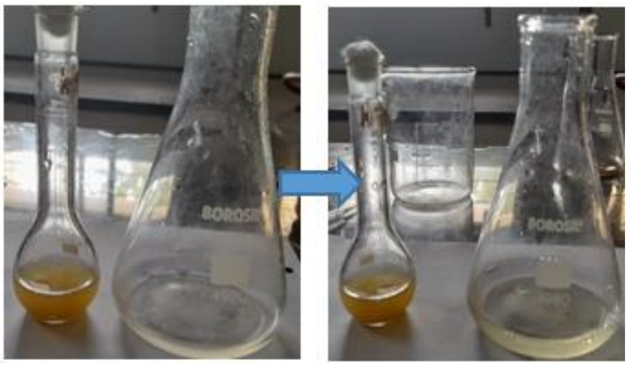


Fig.(k) Watermelon peel extract indicator

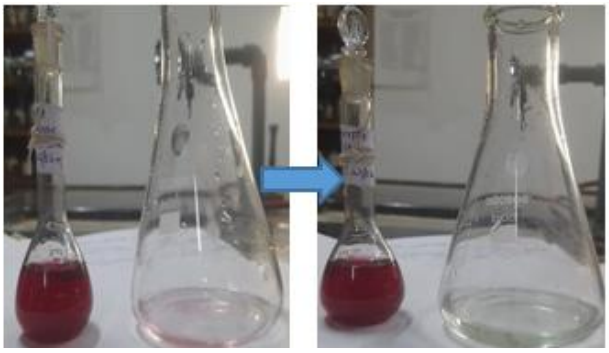


Fig.(l) Purple cabbage extract indicator

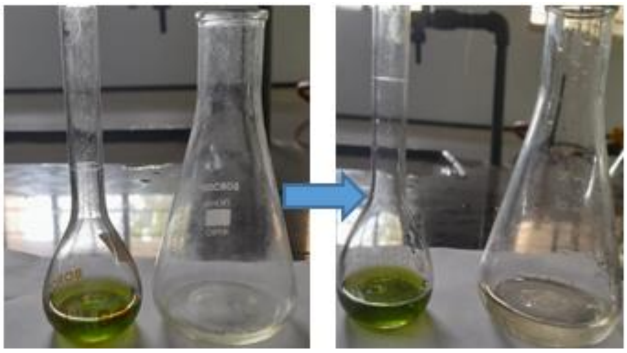


Fig.(m) Spinach extract indicator

Indicator extract via. Ethanol

Titrant vs. Titrand	Indicator	End point	Mean titration reading ± SD
NaOH vs HCl	Methyl orange	Pink to yellow	10±3
	Purple cabbage	Purple to blue	10±2
	Onion peel	Pinkish to greenish	10±2
	Carrot peel	Colorless to yellow	12±3
	Sweet Potato peel	Pink to greenish	10±3
	Apple peel	Pink to yellowish	10±2
	Beetroot peel	Yellowish to colorless	10±2
	Watermelon peel	Colorless to yellow	12±5
	Pomegranate peel	Orange to brown	10±1
	Spinach waste	No color observe	
	Fenugreek waste	No color observe	
	Orange peel	Colorless to green	10±9
Succinic acid vs NaOH	Phenolphthalein	Colourless to pink	10±1
	Methyl orange	Pink to yellow	5±2

 ISSN 2394 - 7780

	Purple cabbage	Purple to blue	10±5
	Onion peel	Light pinkish to greenish	10±0
	Carrot peel	Colorless to yellow	11±5
	Sweet Potato peel	Pink to greenish	10±2
	Apple peel	Pink to yellowish green	10±7
	Beetroot peel	Yellowish to colorless	10±5
	Watermelon peel	No color change	
	Pomegranate peel	Orange to yellow	10±2
	Spinach waste	No color change	
	Fenugreek waste	No color change	
	Orange peel	Colorless to light green	10±5

End point observed for Acid Base titration:

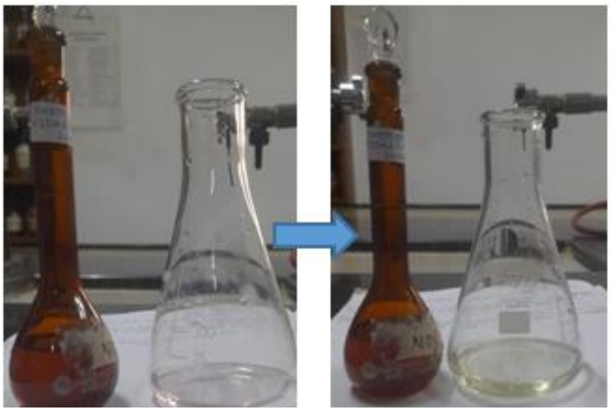


Fig.(n) Sweet potato extract indicator

Fig.(o) Apple peel extract indicator

Fig.(p) Purple cabbage extract indicator

Fig.(q) Onion peel extract indicator

Fig.(m) beetroot peel extract indicator

Fig.(n) Carrot peel extract indicator

International Journal of Advance and Innovative Research
Volume 12, Issue 2: April - June 2025
ISSN 2394 - 7780

UV/ Vis Spectroscopy

1. Ethanol

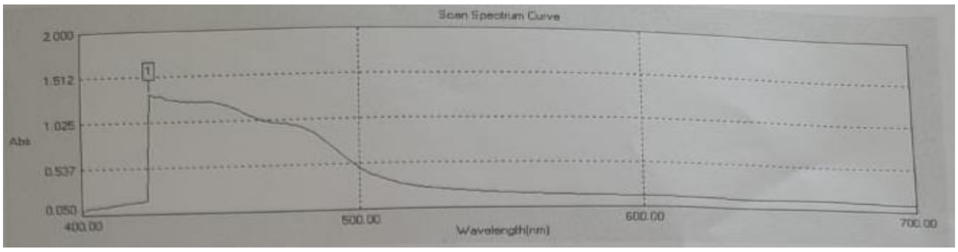


Fig.(1) Orange peel

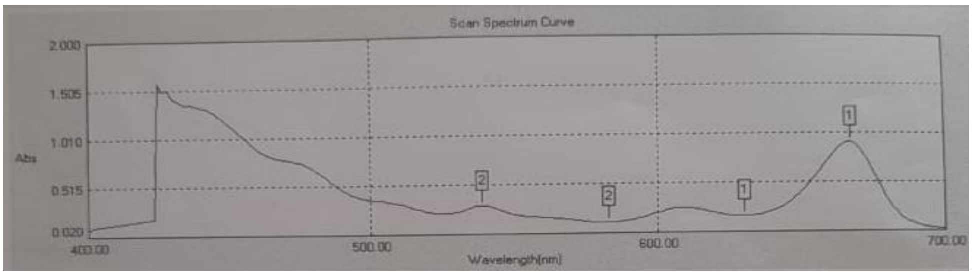


Fig.(2) Onion peel

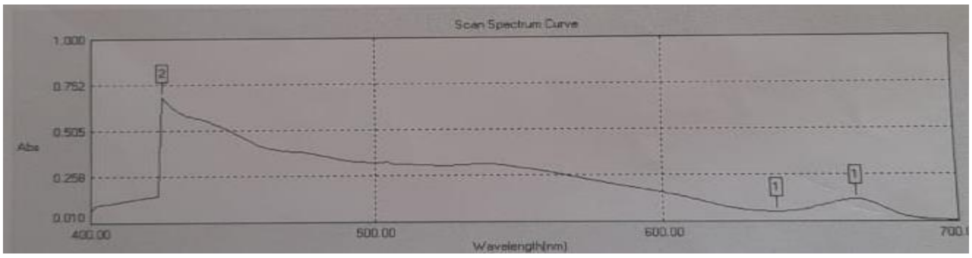


Fig.(3) Spinach

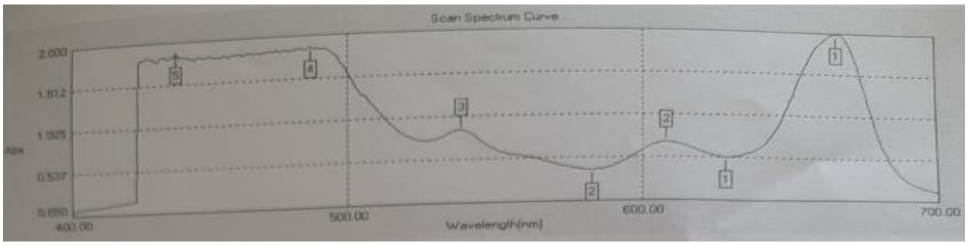


Fig.(4) Purple Cabbage

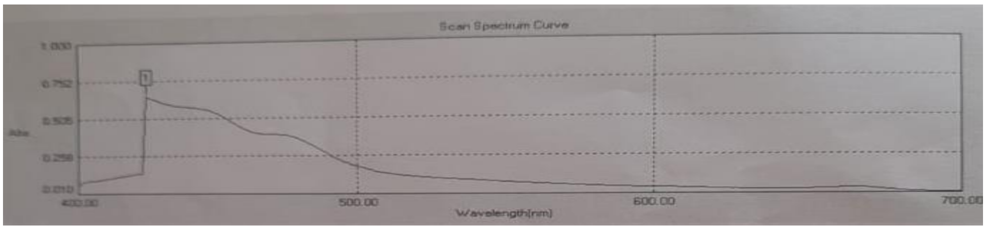


Fig.(5) Watermelon peel

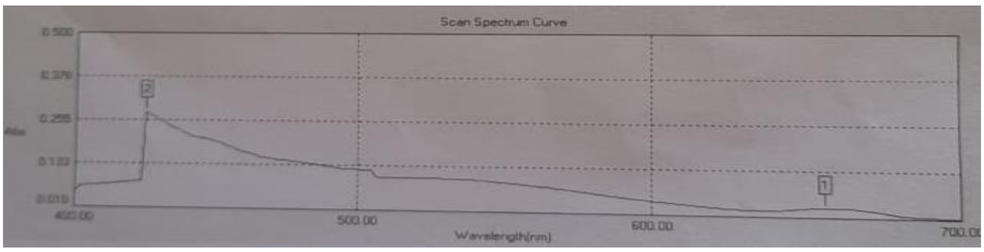


Fig.(6) Banana peel

International Journal of Advance and Innovative Research
Volume 12, Issue 2: April - June 2025
ISSN 2394 - 7780

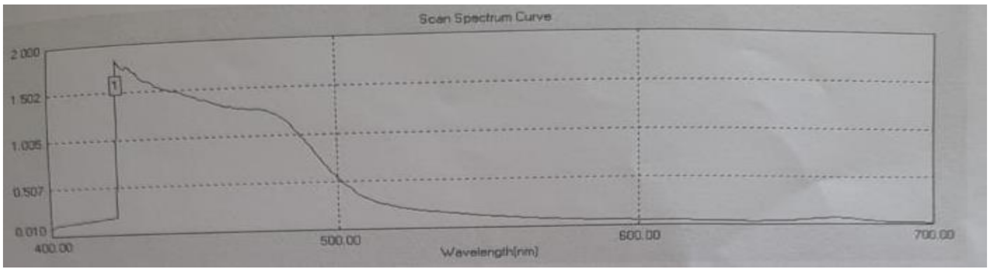


Fig.(7) Sweet potato peel

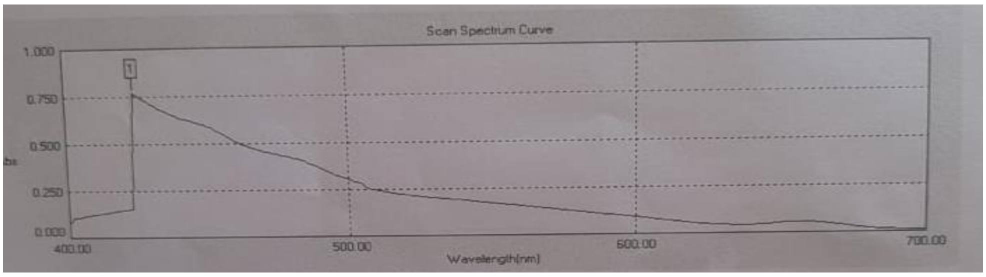


Fig.(8) Beetroot peel

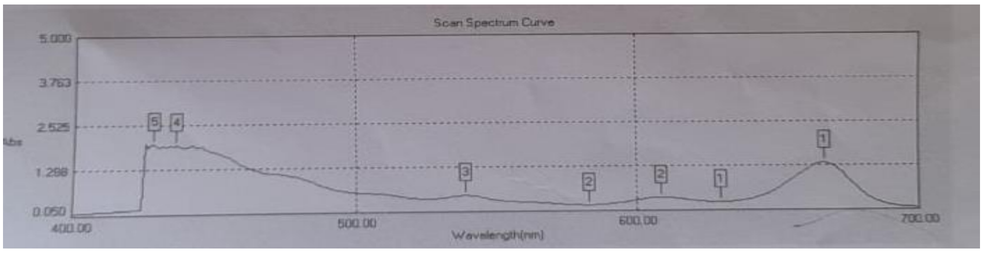


Fig.(9) Apple peel

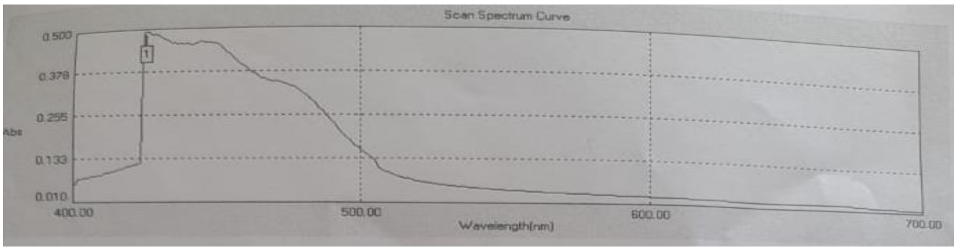
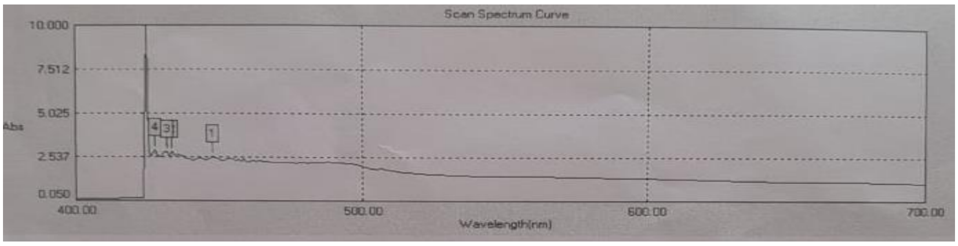


Fig.(10) Fenugreek



Fig,(11) Carrot peel

2. Distilled Water:

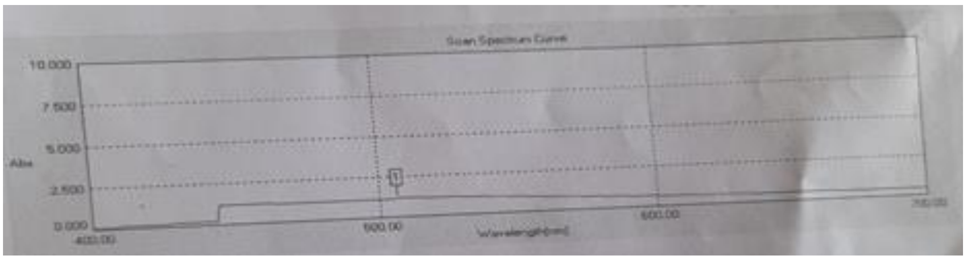


Fig.(12) Sweet potato

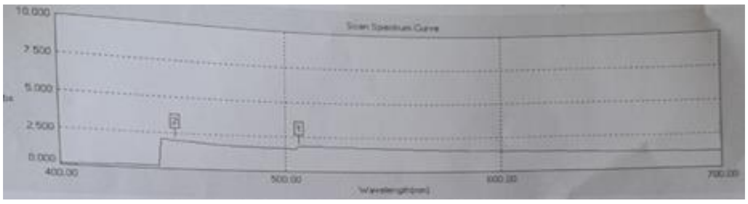


Fig.(13) Apple peel

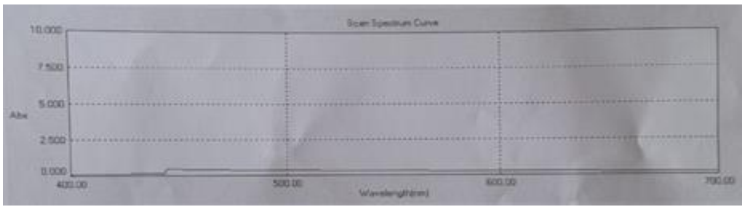


Fig.(14) Watermelon peel

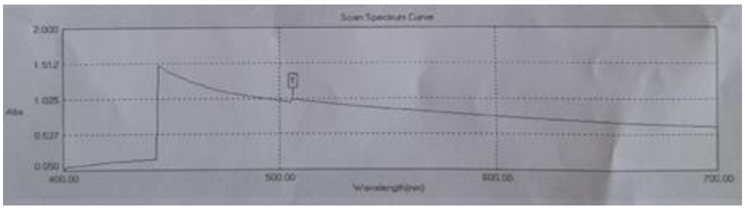


Fig.(15) Carrot peel

Fig.(16) Orange peel

Fig.(17) Pomogranate peel

Fig.(18) Onion peel

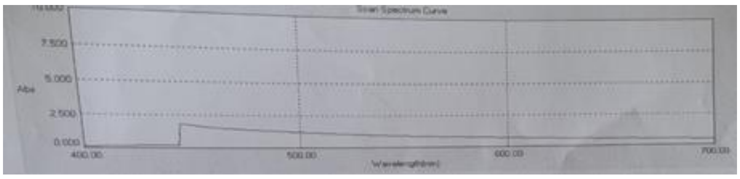


Fig.(19) Purple Cabbage

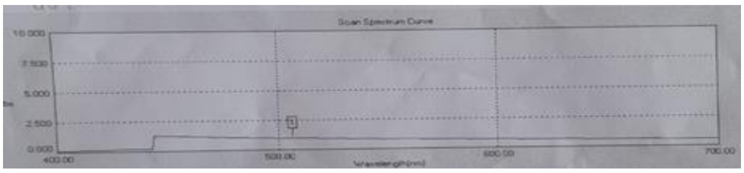


Fig.(20) Beetroot peel

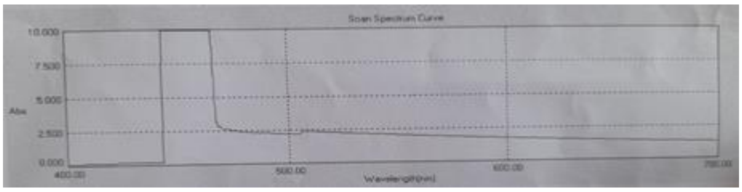


Fig.(21) Banana peel

UV/Vis spectroscopy was carried out on each sample and the absorbance was plotted against wavelength. It shows that the spectra obtain for the ethanol haves the maximum absorbance at particular wavelength while in the case of distilled water it shows least absorbance respectively. From figure 1 and 16, it shows that orange extract using ethanol and water absorbs at λ_{max} of 426 nm and 450 nm, respectively. Figure 2 and 18 shows the onion extract using ethanol shows two to three peaks and water absorbs at λ_{max} of 665 nm and 450 nm, respectively. Figure 4 and 19 shows the purple cabbage extract using ethanol shows four to five peaks and water absorbs at λ_{max} of 665 nm and 424 nm, respectively. Figure 5 and 14 shows the watermelon extract using ethanol and water where it doesn't shows any maximum absorption, but in case of ethanol it absorbs at λ_{max} of 424 nm respectively. Figure 6 and 21 shows the Banana extract using ethanol it absorbs at λ_{max} of 659 nm while in case of water there is no specific absorption observed, respectively. Figure 7 and 12 shows the sweet potato extract using ethanol and water absorbs at λ_{max} of 442 nm and 520 nm, respectively. Figure 8 and 20 shows the beetroot extract using ethanol and water absorbs at λ_{max} of 424 nm and 520 nm, respectively. Figure 9 and 13 shows the apple extract using ethanol shows five major peaks where it absorbs at λ_{max} of 442 nm and 424 nm, respectively..

CONCLUSION:

It opens door for businesses, and academic institutions to invest in the research and implementation of these low-cost, high-impact solutions as part of national sustainability strategies. By doing so, countries can improve environmental monitoring, create new jobs, reduce waste, and drive long-term economic growth. The result obtained from this experiment leads to conclude that the dyes extracted from the vegetable and fruits peel waste can be used as an indicator for acid-base titration for the determination of end point or strength of acids & bases. These indicators are extracted from these organic waste, that are easily available, cheap, economically friendly & easy to extract that is major advantage. The acid base titration performed for strong acid- strong base & weak acid-strong base, the sharp colour change was observed during the titration. In case of strong acid (HCl) - strong base (NaOH), mostly onion peel, sweet potato, purple cabbage, and orange gave colour change to greenish while carrot, beetroot, pomegranate gave colour change to dark color after titration , respectively, there is no sharp color changes observed in case of watermelon with ethanol, spinach and fenugreek with distilled water & ethanol because their colour changes remain same i.e. yellow due to the absent of the anthocyanin group, as it is mainly present in the vegetable and fruits having red or purple color.

It can also be conclude that onion peel, purple cabbage, beetroot peel, orange peel, apple peel, carrot peel is more efficient for acid-base titration due to their sharp colour change, due to anthocyanin compound. These method used was very simple, acceptable, eco-friendly, accurate and inexpensive.

Since its hard to preserve the indicator extracted from the peel via distilled water because of the biological activities it produces a layer of fungus, which can be removed by filtration process and can be reused for three to four weeks and even for one to two month depending upon the atmosphere. While in case of ethanol extraction process the indicator should be store in amber lite standard measuring flask to avoid the direct contact of sunlight as ethanol is volatile in nature due to which it can evaporate easily and leave sticky like substance behind.

REFERENCES:

1. Sashikala, S; Pavithra, A; Priya, V; Pooja, S; Peels of Fruits and Vegetables as Eco-Friendly Natural Indicator in Acid-Base Titrations, IJCRT.ORG, 2320-2882, 2023

2. Maria, B,N; Risnita, V,L; Development of Universal Indicator from Organic Waste Material, Journal of Research in Science Education, JPPIPA 9(4),2023

3. Sharmaa, M; Usmanib, Z; Gupta V,K; Valorization of fruits and vegetable wastes and by-products to produce natural pigments, Critical Reviews In Biotechnology,535–563,2021

4. Nair, K; Kelkar, A; Kshirsagar, S; Harekar, A; Satardekar, K; Barve, S; Kakodkar, S; Extraction of natural dye from waste flowers of Aster (Aster chinensis) and studying its potential application as pH indicator, Journal of Innovations in Pharmaceutical and Biological Sciences (JIPBS) ISSN: 2349-2759,2018

5. Sandeep, B.P; Kondawar, M.S; Ghodke, D.S; Naikwade, N.S; Magdum, C.S; Use of Flower Extracts as an Indicator in Acid-Base Titrations. Research J. Pharm. and Tech, 0974-3618, 2009.

6. Olanrewaju, A.O; Adeosun, N.O; Application of Principles and Tools in Green Chemistry to Education Using Rose Flower Extract as Acid-Base Indicator. J. Chem. Soc. Nigeria, 045-050, 2023.

7. Izonfuo, W. L; Fekarurhobo, G.K; Obomanu, F.G; Daworiye, L.T; Acid-base indicator properties of dyes from local plants I: Dyes from Basella alba (Indian spinach) and Hibiscus sabdariffa (Zobo) J. Appl. Sci. Environ. Mgt, (10) 1 5-8, 2006.

8. Paul, A; Nicolas, E Green; Chemistry: Principles and Practice. Chemical Society Reviews, 06511, 2019.

9. Naruwan, P; Primpak, M; Natthaphol S; Jirapast, S; Natural Indicator for Acid-Base Titration from Thai Yellow Flower Extracts. International Journal of Chemical Engineering and Applications, 10-1 2019.

10. Abbas, S.K; Study of acid-base indicator property of flowers of Ipomoea biloba. International Current Pharmaceutical Journal. 420-422, 2012.

11. Pokharna, G; Jain, N.K; Nalwaya, N; Chatap, V. K; Bougainvillea glabra -A Natural Indicator. pharmacognosy journal, 2010.

12. Abhyangshree, N.M; Dhanashri, S.K; Vinayak, B.K; Use of Combretum Indicum Flower Extract as a Natural Indicator in Acid-Base Titration. International Journal of Institutional Pharmacy and Life Sciences, 2016.

13. Sudarshan, S; Bothara, S.B; Sangeeta, S; Roshan, P; and Reena, U; Acid-Base Indicator Properties of Dyes from Local Flowers Pharmacognosy Journal 3 (19), 2011.

14. Wardencki, W; Curylo, J; Namieœnik, J; Green Chemistry — Current and Future Issues. Polish Journal of Environmental Studies, 389-395, (2015).

15. Abuh,L.O; Shaibu, L.E; Egu,S.A; Omeiza, F.S; Ethanolic Extracts as Substitute Indicators in Acid Base Titrimetry. Journal of Basic and Applied Research International, 25-30, 2018.

16. Padma, S.V; Dhura, B; Rose Anthocyanins as Acid Base Indicators. Electronic Journal of Environmental, Agricultural and Food Chemistry, 875-884, 2010.

17. Mahajan, N.S; Jadhav, R.L; Pimpodkar, N.V; Dias, R.J; Karande, P.P; Use of Canna indica Flower Extract As A Natural Indicator In Acid Base Titration. Journal of Pharmacy Research, 2008.

18. Daniel, A. A; Ohene, B. A; Gregory, P; Investigation of a Simple and Cheap Source of a Natural Indicator for Acid-Base Titration: Effects of System Conditions on Natural Indicators. Green and Sustainable Chemistry, 117-122, 2012.

19. Trupti, S; Ghatage, S.G; Killedar, M.A; Hajare, M; Extraction, Characterization, and Utilization of Different Plant Pigments as PH Indicators in Titrimetric Analysis International Journal of Advance Research, Ideas and Innovations in Technology, 2107.

20. Bhagat, V.C; Patil, R.D; Channekar, P.R; Shetty, S.C; Akarte, A.S; Herbal indicators as a substituent to synthetic indicators. International Journal of Green Pharmacy, 162–163, 2008.