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Eco-Friendly Plant-Based Natural Indicator pH Papers for the Analysis of Household Materials

Badhe Mayur Ramesh

Department of Chemistry, Vasantrao Naik College of Arts, commerce and Barrister A. R. Antulay Science College, Mhasala-Raigad 402105, Maharashtra, India

Abstract: ***This research investigates the creation and usage of acid-base indicator paper derived from the flowers of Syzygium cumini, Delonix regia, and Bougainvillea, using their inherent pigments, mainly anthocyanins, as indicators for pH levels. The extraction technique entails soaking the flower petals in water to release their vibrant colours, which are subsequently transferred onto filter paper, yielding a practical indicator tool. The effectiveness of the paper is assessed across various pH ranges, showing distinct colour transformations that reflect the levels of acidity and alkalinity in different household substances: acidic solutions yield light blue or light green hues, whereas basic conditions produce blue or green shades. Employing these natural indictor papers presents an environmentally friendly substitute for traditional synthetic pH papers and underscores the potential of biological resources for both educational and practical chemistry applications. This study emphasizes the significance of using natural indicator papers to foster sustainable methods of pH measurement while highlighting the aesthetic and functional contribution of plants material in scientific research. In this paper, pH values of different household materials were measured using digital pH meter, Universal pH paper as well as using pH papers made by using Syzygium Cumini Fruit, Delonix Regia Flower and Bougainvillea Glabra Flower.***

Keywords: Household materials, Digital pH meter, pH papers, pH papers made by natural indicators

1. Introduction

The pH value indicates the level of acidity or alkalinity present in a solution. pH is defined for compendial purposes as the value obtained using an adequately calibrated potentiometric sensor and measuring system, traditionally known as a “pH meter”. pH scale allows scientists to work more easily and efficiently [1-2]. Contemporary measurement systems can integrate pH sensors and digitally transmit the pH signal to external devices. Nowadays there are dozens of household products that are part of our environment, many of these help us do housework, they are part of our diet, personal care and controllers of different ailments such as medications. The pH scale is a fundamental concept in chemistry that applies directly to many products and substances we use every day. This scale is applied to all aqueous solutions, where the number 7 is assigned for Neutral solutions, if the water is pure, will have a pH of 7, alkaline substances have a pH > 7 and acidic solutions have a pH < 7 [3-4]. The titrimetric analysis is the most frequently applied method for acid-base estimation or hydronium ion concentration requiring specific chemicals, glassware and handling. On the other hand, pH paper strips are used broadly to test the acidic or basic nature of solution and just like litmus paper are cheap, available easy to use and store as well as show comparable results [5-7]. From the food we eat to the cleaners we rely on, pH determines how a substance behaves, how safe it is to handle, and how effective it will be for a specific task. Knowing the pH of common household items helps you clean more efficiently, cook with better results. This article walks through the pH of typical household substances, explains why it matters, and offers practical guidance for everyday use [8-10].

This analysis attempts to delve into the pH ranges of shampoos and soaps, illuminating their implications for skin and hair care and emphasizing the significance of pH understanding in choosing appropriate products for everyday use. The pH of typical household soap and shampoo varies greatly depending on the brand and kind, according to the search results. With a pH range of 7 to 10, dish soap is typically neutral to mildly alkaline [8-9]. Various plants and flowers that are pink, purple, blue or red coloured contain anthocyanin and can be used to prepare natural pH paper due to their colour changes with pH [11-12]. Most of the pH papers used now a day are synthetic such as pH paper, litmus paper prepared in laboratories and used to determine pH of any substance. These synthetic pH papers are changes colour in solution according to the pH or on change in hydrogen ion concentration [13-14]. Despite these, natural pH papers made from plants like onion, cherry, blueberry, beetroot, red cabbage, peach, pear, grapes, tomato, rose, turmeric, etc. are safe, less expensive, easily available, have fewer side effects, biodegradable, green and eco-friendly [15-16]. We have taken 25 domestic household materials and determine their pH 1-14 for comparison. The results obtained from natural pH paper are the same as from synthetic ones. In addition, the experiment can be carried out at homes in administrative segregation and solitary confinement in case of pandemic to overcome the disruption of learning. Natural indicators are the best alternative for present days as all over the world corona has almost ceased economy and education. Keeping in view all the above premiums researchers are now working in the field of natural indicators as they proved to be safer substituent for commercial indicators [17-19]

2. Material and Method

2.1 Preparation of Fruit Extract (Syzygium cumini)

The recently gathered jamun was carefully rinsed with purified water to eliminate any surface contaminants. A measured amount of jamun pulp or whole raspberries was added to a clean beaker and mixed with 30 mL of distilled water. A glass rod was then utilized to crush the blend allowing for the extraction of anthocyanins and other colour compounds from the

fruits. This blend was subsequently heated to between 50-60 ^{0}C for a period of 10 minutes, with stirring at intervals. After it achieved room temperature, the mixture was filtered through Whatman paper No. 41 filter paper. The resultant mixture liquid was collected in a dark container and stored at 4 ^{0}C, protected from direct light, until it was required.

2.2 Preparation of Flower Extract (Delonix regia and Bougainvillea Flower)

The fresh petals of the flowers were rinsed with purified water to eliminate any leftover particles and subsequently dried by lightly pressing them with absorbent paper. Then, a specific quantity of the petals was finely chopped and placed into a mortar with 30 mL of pure ethanol, where it was thoroughly mashed into a smooth paste. This paste was allowed to sit for 25-30 minutes at room temperature, with occasional stirring, to produce a coloured extract containing anthocyanins and other pigments from the flowers. The coloured extract was then filtered through Whatman No.41 filter paper, and the resulting liquid was collected and stored in a dark amber bottle at 4°C for subsequent research.

2.3 Preparation of pH-paper indicator strips.

Indicator strips are prepared by taking by taking 30g of Syzygium cumini, 250 g of Delonix regia, and 500 g of Bougainvillea Flower.Initially they were cleaned and washed before the extraction procedure to get rid of any pollutants. Petals of flowers are cuts into small pieces and crushed into mortar piston by adding minimum quantity of water. Similarly, Syzygium cumini is boiled, then pulp is separated from seed and crushed into mortar piston. Finally, all the solution was refluxed for about 10-15 minutes allowing the anthocyanins to natural pH indicators and then solution was let cool to ambient temperature. Conventional technique is applied for filtration using Watman filter paper No. 41. Then filter paper is dipped into the plant extract solutions for 30 minutes to get an even hue, then it was air-dried for 12 hours before being cut into 4 cm by 1 cm (length by width) strips. These prepared strips of paper indicators were utilized for identifying the acid-base properties of twenty five common household substances such as milk, soap, toothpaste, honey, ketchup, Garcinia indica, vinegar, tamarind indica, lemon, aspirin tablet, campa solution, sprite, orange juice, disprin tablet solution, coffee solution, red chilli solution, coriander seed solution, turmeric powder solution, shampoo solution, crocin tablet solution, Gelusil tablet solution, talcum powder solution, baking soda, detergent solution and vivel soap solution.

3. Result and Discussion

In our homes, we use a lot of chemicals in our daily life without knowing their nature or properties. To measure the nature or strength of acids and bases pH papers are commonly used. These pH papers are usually cheap, readily available, eco-friendly and easily stored. Anthocyanins are water soluble pigments found in Delonix regia, Bougainvillea Flower and in Syzygium cumini also. It appears red, blue or purple colour depending on pH. Therefore acid-base indicators paper derived from Delonix regia, Bougainvillea Flower and Syzygium cumini serves as natural alternatives for determination of pH level. pH papers purchased from the market which increases their cost and is sometimes not readily available. To overcome this, here we prepared pH paper strips from natural sources (plants) that gave comparable results with synthetic pH papers available in the laboratory. For comparative studies, the acidic or basic nature of twenty five household samples like milk, vinegar, soap, shampoo, toothpaste, etc., was measured at pH range from 2.3-8.4.

Figures 1: Represents the household substance solutions used in the study

3.1 Colour of the prepared natural indicator extracts

The natural indicator extracts were successfully derived from Jamun fruit (Syzygium cumini), the blossoms of Gulmohar (Delonix regia), and the flowers of Bougainvillea (Bougainvillea glabra), as demonstrated in figure 2 shown below. The extracts collected recently exhibited their unique colours. The Syzygium cumini displayed a rich violet colour, the Delonix regia flower showed an orange-red colour and that of bougainvillea flower extract displayed vibrant pinkish-purple shade.

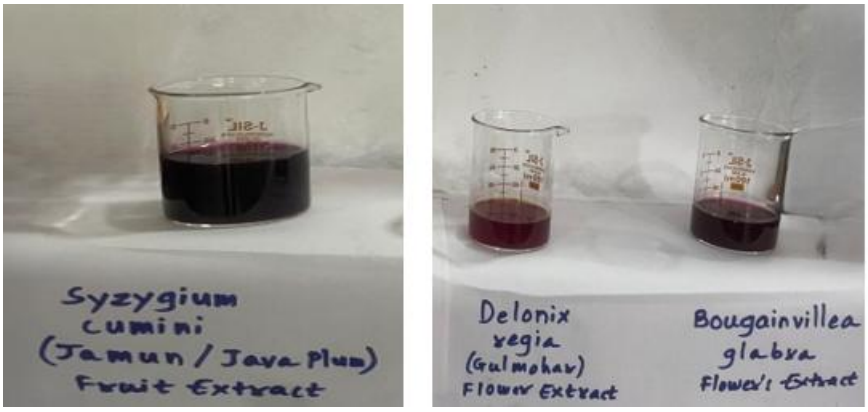

Figure 2: Extract of Syzygium cumini, Delonix regia and Bougainvillea flower

3.2 Determination of pH of plant extract

The acidity of these pure extractions was assessed using a pH meter once the extraction was completed. The table 1 below represents the pH values of the plant extracts utilized in this study. Every extraction exhibited a pH range from 3.42 to 5.02, indicating they were all acidic. Among the various extracts, Jamun (Syzygium cumini) fruit had the lowest pH at 3.42, whereas the Bougainvillea (Bougainvillea glabra) flower extract had the highest pH of 5.02. The acidic properties of these extracts stem from the naturally occurring organic acids and anthocyanin pigments, highlighting their potential as natural indicators of acid-base reactions.

Table 1: pH of plant extract

Sr. No.	Plant Extract	pH
1	Syzygium cumini fruit extract	4.02
2	Delonix regia flower extract	4.86
3	Bougainville flower extract	5.54

3.3 Detecting the Nature of Household Samples

Among the tested household chemical, garcinia indica is supposed to be the strongest acid due to the lowest pH value of 2.33. garcinia indica turns pH paper into red indicating its pH below 03. But there is no change observed for indicator papers made by Delonix regia, Bougainvillea Flower and Syzygium cumini Similarly, vinegar solution also showed a pH near 2.58. Lemon juice at 2.63, campa solution at 2.96, aspirin tablet solution at 2.91 and tamarind indica juice is at 2.63 are also acidic due to the presence of citric acid, acetylsalicylic acid, tartaric acid, phosphoric acid and acetic acid ranges 2-3. For campa and aspirin tablet solution pH paper turns yellow and for lemon juice and tamarind indica juice pH paper turns to yellowish brown. For all these household samples, Syzygium cumini indicator paper turns to light blue colour. Delonix regia paper turns to light green colour and Bougainvillea flower indicator paper showed no colour change for samples like lemon juice, campa solution aspirin solution and tamarind juice but for vinegar sample solution Bougainvillea flower indicator paper showed faint yellow colour.

Most household chemicals like red chilli, ketchup, milk, coffee, turmeric powder, coriander seed solution, disprin tablet solution, honey sample and orange fruits contain small amounts of citric acid, malic acid, ascorbic acid and lactic acid therefore supposed to be weak acids or mild acids with a pH value 4-6. For these, pH indicator strips showed no colour change. For household samples like honey, tomato ketchup, disprin tablet solution Syzygium cumini indicator

paper showed blue colour while Delonix regia paper turns to light green colour for the samples like coffee, honey, coriander seed solution, tomato ketchup, disprin and orange fruit but for the red chili and milk samples Delonix regia paper showing no colour change. Bougainvillea flower indicator paper showed no colour change for samples like red chilli, ketchup, milk, coffee, turmeric powder, coriander seed solution, disprin tablet solution and orange fruits but only for honey sample paper turns to faint yellow colour. All these household samples show positive potential because of presence of their natural acidity and high concentration of hydrogen ions.

Other household samples like toothpaste, crocin tablet solution, santoor soap solution and shampoo etc showed pH values between 6-6.9. For such household samples, pH papers showed yellow colour. Syzygium cumini indicator paper showed blue colour for toothpaste, crocin tablet solution, shampoo samples but for the santoor soap solution paper turns to light blue in colour. For Delonix regia paper turns to light green colour and Bougainvillea flower indicator paper showed light yellow colour for shampoo solution and toothpaste samples but for santoor soap solution and crocin tablet solution there is no change inBougainvillea flower indicator paper.

Some household chemicals are weakly basic in nature e.g., baking soda, talcum powder and Gelusil tablet solution etc. Such samples showed a change in synthetic pH indicator papers turn to light green colour for baking soda and Gelusil tablet solution but for talcum powder solution pH paper show yellow colour. Syzygium cumini indicator paper showed green colour for baking soda, light blue and blue colour for talcum powder solution and Gelusil tablet solution. Baking soda and talcum powder turns Delonix regia paper to light green colour and for talcum powder it turns to green colour. Bougainvillea flower indicator paper turns to yellow colour for household samples like talcum powder and Gelusil tablet solution but it turns to yellowish green for baking soda solution.

In our daily life, we use some household chemicals that are strongly basic like detergent powder (Tide), bath soap (Vivel soap) etc. For such types of samples indicator paper changes to green and light green colour while Syzygium cumini indicator paper showed green colour for detergent solution and dark blue colour for Vivel soap solution. Similarly, Delonix regia paper turns to light green colour for Vivel bath soap solution and turns to green colour for Tide detergent solution. Bougainvillea flower indicator paper showed yellowish green colour for Tide detergent solution and Vivel bath soap solution. Household samples like baking soda, talcum powder, Gelusil tablet solution, detergent powder (Tide) and bath soap (Vivel soap) shown negative potential because of mild and moderate alkaline nature and hydrophobic nature. Overall, we used 25 domestic household materials and determine their pH using pH indicator paper and compared with natural indicator paper. The synthetic indicators show colour change in acid-base titration will be summaries in table 2. The result obtained by using natural indicator papers will be displayed in table 3

Table 2: pH range of some synthetic indicator

S/N	Indicators	In Alkaline Medium	In Acidic Medium	pH Range
1	Alizarin yellow	Red	Yellow	10.1–12.0
2	Bromothymol blue	Blue	Yellow	6.0 – 7.6
3	Litmus paper	Blue	Red	5.0 – 8.0
4	Methyl orange	Yellow	Red	3.1 – 4.6
5	Methyl red	Yellow	Red	4.4 – 6.3
6	Methyl violet	Violet	Yellow	0.0 – 1.6
7	Phenolphthalein	Pinks	Colourless	8.3 – 10.0

Table 3: The colour scale of Syzygium cumini, Delonix regia and pink Bougainvillea at different pH ranges

Sr. No.	Sample	Potential (mv)	Acidic pH	Basic pH	Natural Indicators		
					Syzygium cumini colour	Delonix regia Flower colour	Bougainvillea Flower colour
1	Garcinia Indica Solution (Kokum)	303	2.33	---	Pink	Gray	Brownish cream
2	Vinegar Solution	288	2.58	---	Light Blue	Light Gray	Faint Yellow
3	Tamarind Indica Solution (Chinch)	279	2.63	---	Light Pink	Light Gray	Faint Brownish Pink
4	Lemon Juice	280	2.63	---	Light blue	Light Gray	Faint Brownish Pink
5	Aspirin Tablet Solution	258	2.91	---	Light blue	Light Gray	Faint Brownish Pink
6	Campa Cold drink	255	2.96	---	Grayish blue	Light Gray	Brownish cream
7	Sprite	221	3.40	---	Grayish blue	Gray	Light cream
8	Honey Solution	219	3.48	---	Blue	Grayish green	Yellow
9	Tomato Ketchup Solution	187	3.83	---	Blue	Light Grayish green	Light Yellowish cream
10	Orange Juice	186	3.86	---	Light Grayish Blue	Faint Gray	Light Yellowish cream
11	Disprin Tablet Solution	175	4.03	---	Blue	Light Gray	Light Yellowish cream
12	Coffee Solution (Nescafe)	113	4.82	---	Grayish Blue	Brownish gray	Light brownish cream
13	Red Chilli (Capsicum Annum) Solution	103	4.94	---	Light Grayish Blue	Light Brownish gray	Light brownish cream
14	Coriander Seed Solution	084	5.22	---	Light Grayish Blue	Light gray	Light brownish cream
15	Milk	028	5.93	---	Grayish Blue	Light gray	Light Yellowish cream
16	Turmeric Powder	015	6.09	---	Grayish Blue	Light gray	Light brownish cream
17	Toothpaste Solution (Colgate)	-009	6.43	---	Blue	Light gray	Faint Yellow
18	Shampoo Solution (Sunsilk)	-017	6.53	---	Blue	Light green	Faint Yellow

19	Crocin Tablet Solution	040	6.85	---	Blue	Light green	Light Yellowish cream
20	Santoor Soap Solution	-051	6.98	---	Light blue	Light green	Light Yellowish cream
21	Gelusil Tablet Solution	-061	---	7.11	Blue	Light green	Yellow
22	Talcum Powder (Ponds)	-065	---	7.15	Light blue	green	Yellow
23	Baking Soda Solution	-073	---	7.26	Green	Light green	Yellowish green
24	Detergent Powder Solution (Tide)	-152	---	8.29	Green	green	Yellowish green
25	Vivel Soap Solution	-154	---	8.33	Dark Blue	Light green	Yellowish green

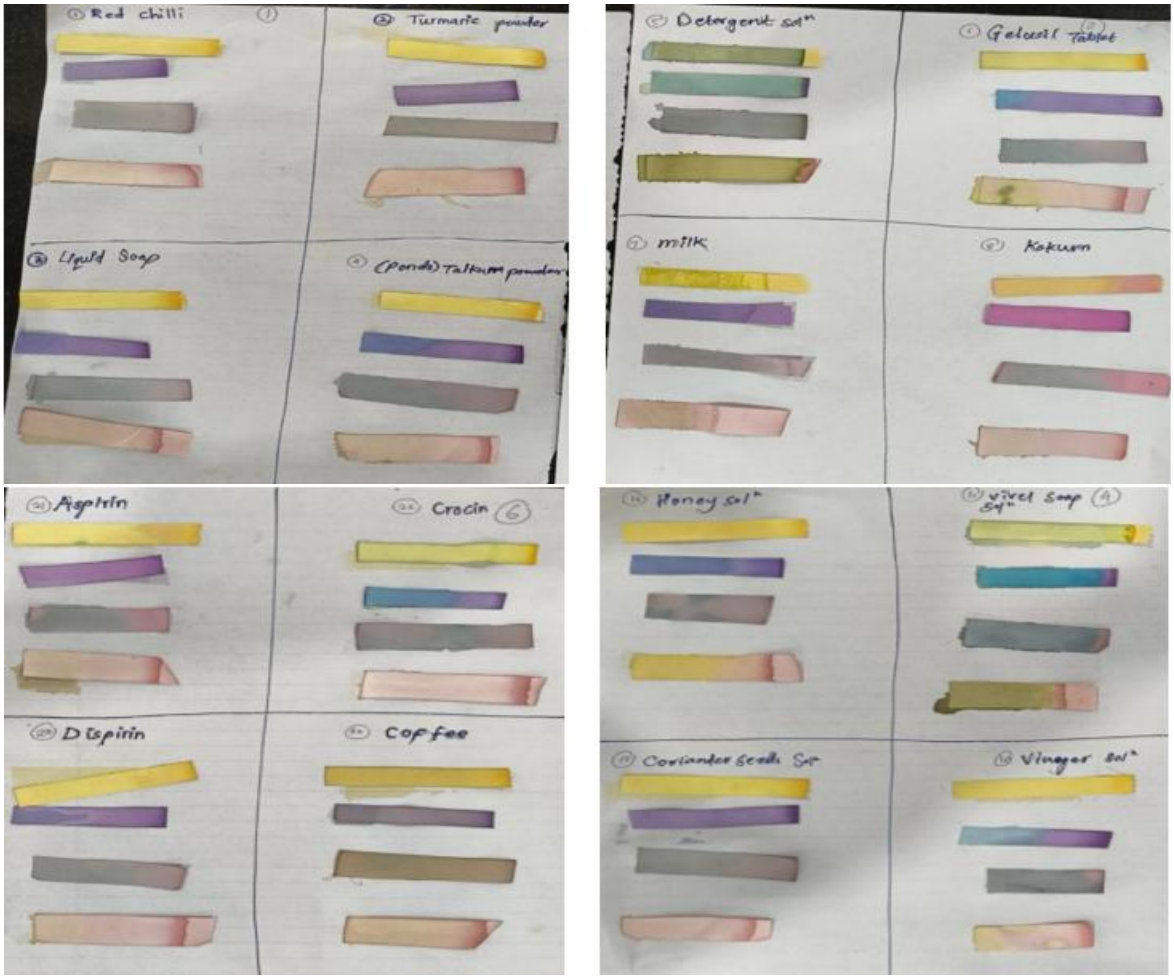

Figure 3: Colour responses of pH paper and natural indicator papers of various household materials.
Order of paper (Top to Bottom) = Synthetic pH paper, Syzygium cumini paper, Delonix regia paper, Bougainvillea extract paper

4. Conclusion

Natural substances were utilized to create acid-base indicator papers, with extracts from Syzygium cumini, Delonix regia, and Bougainvillea flowers being effective in assessing the characteristics of different household substances or solutions. The calibration data obtained for all natural indicator papers in the pH range of 2.3 to 8.4 demonstrated notable changes in coloration. Therefore, by employing Whatman 41 paper, it is feasible to mix these extracts to produce acid-base indicator papers. When these papers were immersed in various household solutions, they exhibited distinct colour changes, such as light green, light blue, green, blue, yellow, and yellowish green. The indicator papers derived from natural materials offered several benefits, including cost-effectiveness, accessibility of resources, and colour fading. Additionally, these materials help mitigate environmental pollution and exhibit greater durability compared to liquid indicators derived from natural sources.

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