

Use Of Three Different Hibiscus Sabdariffa L. Varieties As An Alternative Color Indicator During Acid/Base And Base/Acid Titration

Abba Diarra Kone, Ibrahima Diallo, Birane Diop, Awa Diop, Papa Biram Sy,
Maty Niass, Bédié Mbow, Mouhamadou Fofana, Alioune Fall
Égal Contribution

Abstract :

Hibiscus sabdariffa L. is widely used in Senegal and around the world as a juice and in cooking (beverages). The aim of this study is to demonstrate the potential of hibiscus as an alternative color indicator in acid/base titrations and vice versa. Hibiscus retains its natural color (depending on the variety) in acidic media and gives a dark green color in basic media (for all three varieties). Extracts of the three Hibiscus varieties, namely white, common, and Vimto, can all be used as color indicators in acid/base titrations and vice versa. Phenolphthalein was used as the reference indicator. Several parameters were tested, including the influence of the solvent, the concentration of the Hibiscus, and the storage temperature. The equivalent volumes obtained with phenolphthalein are practically identical to those obtained using the different Hibiscus varieties. This experiment shows that the values obtained with the Vimto variety (Roselle or Guinea sorrel) are closer to those obtained with the reference (phenolphthalein) with a clear appreciation of the equivalent point. Each dosage was repeated three times and the average volume was calculated.

Keywords : *Hibiscus Sabdariffa L.*, colour indicator, acid/base titration.

Date of Submission: 27-02-2026

Date of Acceptance: 07-03-2026

I. Introduction :

Colored indicators are acidic or basic species that exhibit different colors depending on the medium in which they are found and in small quantities [1]. They are often used in chemistry during volumetric titrations between an acid and a base, or vice versa, to identify equivalence points. They are also used to determine the acidic or basic nature of an unknown solution. Synthetic indicators commonly used have certain drawbacks, such as chemical pollution, limited availability, and high production costs. It is in this context that this study aims to find an alternative to colored indicators using *Hibiscus* extracts. Phenolphthalein is carcinogenic [2].

During soap production in the laboratory, using *Hibiscus vimto* as an additive, it was observed that the *Hibiscus* exhibited different colors depending on the pH of the medium. This observation led us to believe in the potential use of hibiscus as a color indicator in acid/base and base/acid titrations, thus offering a simple and environmentally friendly alternative for green chemistry. This plant has various vernacular names, such as Karkadé, Guinea Sorrel, Sudan Sorrel, Roselle, Rose Tea, Pharaoh's Drink, in Wolof 'Bissap', and in Sudanese 'Dâ-koumou'. In English, the plant is known as 'Carcade', Roselle, Jamaica sorrel, and Jamaica red sorrel' [3]. Three varieties are consumed in Senegal, including Vimto red-calyx, light red h, and white *Hibiscus*. The objective of this study is to explore the use of these three Senegalese hibiscus varieties as color indicators in acid-base titrations and inversely.

II. Materials And Methods

Plant materials

The different varieties of *Hibiscus Sabdariffa L.* (Ordinary, Vimto, and White) were purchased at the market (Dakar) and then ground into a very fine powder using an electric grinder (STPE-1020W; Smart technology), and then sifted. Figure 1 shows the different Hibiscus varieties studied before and after grinding.



Figure 1 : Different varieties of *Hibiscus Sabdariffa L.* [4], [5]

Laboratory equipment:

Standard equipment was used to carry out this work. Appropriate glassware: a graduated burette allowing for progressive dosing, a graduated pipette with a pro-pipette for measuring volumes, beakers, erlenmeyer, test tubes, volumetric flask, a magnetic stirrer, a magnetic stir bar.

Method

The method used in this work is volumetric acid/base or base-acid titration. Aqueous solutions of hydrochloric acid (HCl) and sodium hydroxide (NaOH) at concentrations of 0.1 N were prepared for the purposes of the experiment. The equivalence points of the titrations were checked using a solution of hibiscus obtained by cold maceration and phenolphthalein as reference. For each titration, one coarse test and two precise tests were performed. The powder of each *Hibiscus* variety was used to prepare 1% hydroethanolic (150/100) (v/v) macerates with 0.25 g of material. The mixture was shaken at room temperature for 30 min, then filtered and stored. A phenolphthalein solution was prepared in the same way.

III. Results Et Discussion

Appearance of indicators depending on the solvent used

A color indicator is an acidic or basic substance that can change color depending on the pH of the environment in which it is found. As a reminder, phenolphthalein is colorless in an acid environment and pink in a basic one. Hibiscus Vimto (dark red), White (light yellow), and Ordinary (light red) retain their respective appearances (color) in an acidic environment. However, in a basic environment, Hibiscus Vimto is dark green. This is consistent with studies conducted by Armando Carrasquero-Durán and Beatriz Navas on the effect of pH on the color of an alcoholic extract of red *Hibiscus* and the determination of the pK_a. The color change is thought to be associated with the dissociation of flavilium (anthocyanin) ions according to the equation: $\text{HAn} \leftrightarrow \text{H}^+ + \text{An}^-$, thus showing that anthocyanin molecules are responsible for the color change depending on whether the environment is acidic or basic [6]. Indeed, anthocyanins, or polyhydroxyflavilium ion glycosides, represent the most important group of water-soluble pigments present in plants. They are responsible for the blue to red colors in many leaves and flowers. The molecular structure of an anthocyanin is illustrated in Figure 2. The white variety, in a basic medium, produces a pale yellow color, and the common variety, a light green color. It should be noted, however, that all three varieties retain their natural colors in a neutral medium.

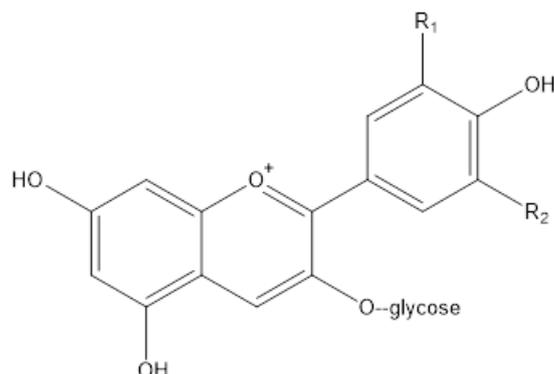
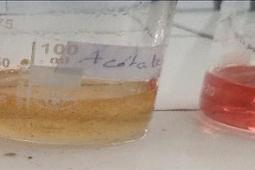
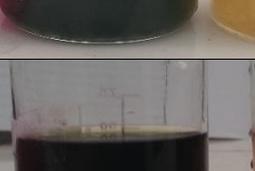
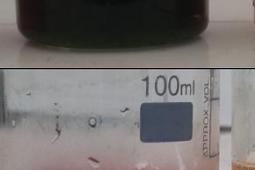
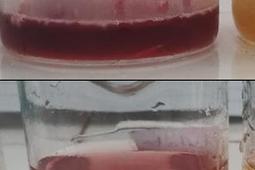


Figure 2 : Structure of an anthocyanin molecule [6]

Solution	<i>Hibiscus sabdariffa L.</i>			
	Phenolphthalein	Vimto	White	Ordinary
Weak Acid CH ₃ COOH				
Strong Acid HCl				
Weak Base NH ₃				
Strong Base NaOH				
Cold Water				
Water at 25°C				

Scheme 2 : The color of the indicators (*Hibiscus*) depends on the pH (acidic or basic) of the solution.

In a neutral environment like tap water, indicator *Hibiscus* retains its natural color. However, in cold (below 25°C) and neutral environments like tap water, the hibiscus color is observed to be darker. Furthermore, the stronger the base, the more intense the hibiscus color.

Testing of different *Hibiscus* varieties as an indicator in comparison with phenolphthalein

This study consisted of performing volumetric acid/base titrations using *Hibiscus* extracts as color indicators. Initially, three hibiscus varieties [Vimto, Ordinary (light red), and White] were tested as color indicators. The results obtained are compared with those obtained using phenolphthalein (Table 1). To obtain greater precision, direct titrations of hydrochloric acid (HCl) with sodium hydroxide (NaOH) and vice versa were carried out. Each experiment was repeated three times (one rough and two precise tests), and the average volume was calculated. Apart from factors that could influence the equivalence point of the volumetric titration of HCl, the three hibiscus varieties proved to be very effective. The average equivalence volumes were 10.10 mL for the Vimto variety, 10.33 mL for the Ordinary variety, and 10.57 mL for the White variety. This difference could be due to a problem in accurately assessing the color at the equivalence point. It should be noted that with phenolphthalein, an average equivalence volume of 10.05 mL (Table 1) was obtained. We also observe that the equivalence volume values obtained with the different varieties and those obtained with phenolphthalein are very

close. In other words, the difference is not highly significant. This allowed us to continue the studies with the Vimto variety, optimizing the various parameters to achieve greater accuracy.

Table 1 : Preliminary tests of different Hibiscus varieties as an indicator in comparison with phenolphthalein.

NaOH (10mL, 0,1N)				
Ind 1‰	Phenophtalein	Hibiscus Vimto	Hibiscus Ordinary	Hibiscus White
HCl (0,1 N)	11	10	10	11
	10,8	10	10,7	10
	9,3	10,3	10,3	10,7
	10,05	10,10	10,33	10,57
HCl (10mL, 0,1N)				
NaOH (0,1 N)	9	9	9	9
	8,2	8,6	8,6	8,6
	8,4	8,5	8,5	8,5
	8,53	8,70	8,70	8,70

When titrating 10 mL of 0.1 N sodium hydroxide with 0.1 N hydrochloric acid, the average equivalent volumes obtained respectively with phenolphthalein, Vimpto, Ordinary and White are 8.53; 8.70; 8.70 mL.

Influence of Vimto concentration on the dosage

The values obtained during this experiment are shown in Table 2. The influence of the concentration of Hibiscus Vimto on the direct titration of HCl (10 mL, 0.1 N) and NaOH (10 mL, 0.1 N) was studied. Solutions with concentrations of 2‰, 3‰, 4‰, 5‰, 6‰, and 7‰ were prepared. This experiment revealed that the 3‰ concentration gave an average value of 9.87 mL, approximately equal to 10 mL, within 0.05 mL. We note that with phenolphthalein, the values are greater than 10 mL, with an absolute difference greater than 0.2 mL. In contrast, the values obtained with the 3‰ Vimto solution are significantly less than 0.2 mL, which is very promising.

Table 2 : Results of the dosage

NaOH (10mL, 0,1N)						
H.Vimto	2 ‰	3 ‰	4 ‰	5 ‰	6 ‰	7 ‰
HCl (0,1 N)	11	10	10	10	10	9
	10,7	9,9	9,3	9,3	8,7	8,2
	10,5	9,7	9,5	9,1	8,9	8,1
	10,73	9,87	9,60	9,47	9,2	8,43
HCl (10mL, 0,1N)						
NaOH (0,1 N)	8	9	9	9	9	9
	7,5	8,8	8,2	8	8,5	8,5
	7,7	8,7	8,1	8	8,5	8,7
	7,73	8,83	8,43	8,33	8,67	8,73

Influence of the quantity of hibiscus and the solvent

In the third part of the experiment, we studied the influence of the quantity of hibiscus and the maceration solvent used. The results of this experiment are presented in Table 3. After analysis, we observed that 3 ‰ hydro-alcohol, with quantities of 2 mL and 3 mL (10 mL), gave the best results, followed by 100 ‰ aqueous solution with quantities of 1 mL to 3 mL (10.2 mL), with values close to the previous one. In order to comply with green chemistry principles and avoid solvents that can directly or indirectly influence preservation results, we adopted water as the solvent.

Table 3 : Results of the influence of the quantity of Hibiscus and the solvent

NaOH (10 mL, 0,1 N)						
	H. Vimto 3 ‰	1 mL	2 mL	3 mL	4 mL	5 mL
HCl (0,1 N)	Ethanol	10,7	9,9	9,8	9,5	9,9
	Ethanol/Water	10,8	10	10	9,7	9,9
	Water	10,2	10,3	10,2	10,5	10,5
HCl (10 mL, 0,1 N)						
NaOH (0,1 N)	Ethanol	8,5	8,6	8,4	8,8	8
	Ethanol/Water	8,4	8,6	8,7	8,8	8,1
	Water	8,6	8,4	8,2	8,2	8,2

Influence of storage (at 4°C) of the macerate solution

The optimization of the various parameters of said dosage, in particular, on the influence of the shelf life shown in Table 4, has made it possible to give a better assessment of this experiment.

Table 4 : Results of Influence of storage (at 4°C) of the macerate on the acid/base and base/acid ratio.

NaOH (10 mL, 0,1 N)				Jour
Ind (H ₂ O) 3 ‰	<i>Hibiscus Vimto</i>	<i>Hibiscus Ordinary</i>	<i>Hibiscus White</i>	1
HCl (0,1 N)	10,2	10,5	10,6	
	10,3	10,4	10,4	
	10,5	10,2	10,2	
HCl (10 mL, 0,1 N)				
NaOH (0,1 N)	8,6	8,7	8,8	
	8,4	8,5	8,6	
	8,2	8,3	8,5	
NaOH (10 mL, 0,1 N)				
Ind (H ₂ O) 3 ‰	<i>Hibiscus Vimto</i>	<i>Hibiscus Ordinary</i>	<i>Hibiscus White</i>	
HCl (0,1 N)	10,7	10,7	10,5	
	10,6	10,6	10,4	
	10,4	10,5	10,5	
HCl (10 mL, 0,1 N)				
NaOH (0,1 N)	8,5	8,3	8,5	
	8,2	8,2	8,2	
	8,3	8,3	8,3	
NaOH (10 mL, 0,1 N)				21
Ind (H ₂ O) 3 ‰	<i>Hibiscus Vimto</i>	<i>Hibiscus Ordinary</i>	<i>Hibiscus White</i>	
HCl (0,1 N)	10,2	10,3	10,6	
	10,4	10,4	10,5	
	10,4	10,3	10,4	
HCl (10 mL, 0,1 N)				
NaOH (0,1 N)	8,5	8,5	7,9	
	8,1	8,8	7,7	
	8,4	8,3	7,9	

The results recorded in the table above show that the storage time (4°C) of the hibiscus extracts does not influence the acid-base titration. It is very difficult to determine the equivalence point using both varieties (Ordinary and White) at the optimal concentration and volume. In contrast, the values for the Vimto variety remain consistently stable, with a strong color at the equivalence point.

IV. Conclusion :

This work aimed to demonstrate that *Hibiscus sabdariffa L.*, a local plant available in Senegal, can serve as a natural color indicator in acid-base titrations, replacing phenolphthalein, a synthetic indicator that is often expensive and not readily available in schools. Through comparative experiments, we tested three hibiscus varieties: Vimto, common, and white, to analyze their effectiveness in identifying the equivalence point. Among them, the Vimto variety stood out due to its clear color transition, good visibility, and superior stability over time.

We also studied several experimental parameters to improve the indicator's effectiveness. The optimal extract concentration is 3 ‰, as this provides a clearly visible color and a precise equivalence point. The ideal solvent is water alone, as it is environmentally friendly, readily available, and ensures good extract stability. The effective amount of extract is 3 mL in a titration. Cold storage (at 4°C) allows the indicator properties to be retained for at least 21 days without significant loss of quality.

Bibliographic Reference

- [1] R. Mahé, « Expériences Portant Sur La Notion D'indicateur Coloré », Vol. 92, 1998.
- [2] « Phénolphtaléine. Laboratoire De Chimie - Fiche - Inrs ». Consulté Le: 14 Février 2025. [En Ligne]. Disponible Sur: <https://www.inrs.fr/Media.Html?Refinrs=Fas%2033>
- [3] « Hibiscus Sabdariffa - Karkadé Culture Et Entretien ». Consulté Le: 16 Juillet 2024. [En Ligne]. Disponible Sur: http://nature.jardin.free.fr/2020/Hibiscus_Sabdariffa.html
- [4] « Feuilles-Hibiscus.Jpg (Image Webp, 753 × 492 Pixels) ». Consulté Le: 16 Juillet 2024. [En Ligne]. Disponible Sur: <https://www.secretsdemiel.com/wp-content/uploads/2022/10/Feuilles-Hibiscus.jpg>
- [5] « Fleur D'hibiscus Séchée Bio, Bissap - Bienfaits, Recettes, Culture ». Consulté Le: 16 Juillet 2024. [En Ligne]. Disponible Sur: <https://www.epices.com/herboristerie/20-fleur-d-hibiscus.html>
- [6] A. Carrasquero-Durán Et B. Navas, « Effect Of The Ph In The Color Of An Alcoholic Extract Of Red Hibiscus And Pkh Determination », Chem. Educ., 2003.