Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 11, Issue 1, 2023

Preparation of Acid-Base Indicators using Extract from Petals of Pride of Barbados (*Caesalpinia pulcherrima*) Flowers

*[1]Dallatu Ephraim Musa, [2]Okorafor Lydia Mariette, [2]Akhagbeme John Osilama and [2]Wilson Arthur Sotonye

[1]Department of Chemistry, Federal University, Lokoja, Kogi State, Nigeria

[2]Department of Biochemistry/ Chemistry, Federal Polytechnic, Nasarawa, Nasarawa State, Nigeria

*Corresponding author:emuda4real@yahoo.com and ephraim.dallatu@fulokoja.edu.ng

ABSTRACT

Reagent indicators are mostly weak acidic substances which by changing colour, show whether solutions or substances are acidic or alkaline. *Caesalpinia pulcherrima* indicator papers were prepared by extracting its colouring matter from about 1 kg petals of *Caesalpinia pulcherrima* flowers through blending and sieving. Moisture content of the petals was determined as 66.00 ± 0.118%. Reddish pink and light green of *Caesalpinia pulcherrima* flowers indicator papers were prepared from extract of the petals. The reddish pink papers turned light green in alkaline solutions and retained their colour in acidic solutions. On the other hand, the light green paper turned reddish pink in acidic solutions and retained their colour in alkaline solutions. pH of the reddish pink and light green extract solutions were 4.20 and 8.90 respectively. The indicator papers were validated in comparison with standard litmus papers as a control: red litmus paper functioned 420 doublet times in 0.2M HCl and NaOH while the prepared reddish pink *Caesalpinia pulcherrima* paper functioned 400 times. As the blue litmus papers functioned 660 doublet times, the prepared light green *Caesalpinia pulcherrima* indicator papersflowers paper functioned 220 times. Percentage (%) performance of the prepared papers was measured and it showed that reddish pink *Caesalpinia pulcherrima* papers performed 95.23% of red litmus paper while the light green *Caesalpinia pulcherrima* papers performed 33.33% of blue litmus papers.

Keywords: Indicator, petals, flowers, *Caesalpinia pulcherrima*, pH, acidic and alkaline.

INTRODUCTION

Caesalpinia pulcherrima is a species of flowering plantin the peafamily *Fabaceae*. It is native to the tropics and subtropics of the Americas. Although it may be native to the West Indies, its exact origin is unknown due to widespread cultivation [1]. Common names for the *Caesalpinia pulcherrima* include poinciana, peacock flower, red bird of paradise, Mexican

bird of paradise, dwarf - poinciana, pride of Barbados, flos pavonis, and *flamyant-de-jardin.* Plate 1 shows an image of pride of Barbados

Plate 1: *Caesalpinia pulcherrima* Tree [1]

Usefulness of *Caesalpinia pulcherrima* has been reported: all seeds of *Caesalpinia* are potentially poisonous, except some species such as *C. pulcherrima* (only eaten before ripening) or *C. bonduc* (only eaten after roasting) [2]. The leaves, flower, bark, and seeds of *C. pulcherrima* were also used by American Indiansin traditional medicine as abortifacients and for suicideby enslaved peoples [2]. *Caesalpinia pulcherrima* is reported to be a striking ornamental plant widely grown in both home and public gardens during warm and mild winters, with beautiful inflorescences of yellow, red and orange [3].

According to Prabavathy *et al* [4] the colouring matter or pigment (colourant) in petals of *Caesalpinia pulcherrima* flowers are anthocyanins whose general molecular – structural formula is shown in Figure 1.

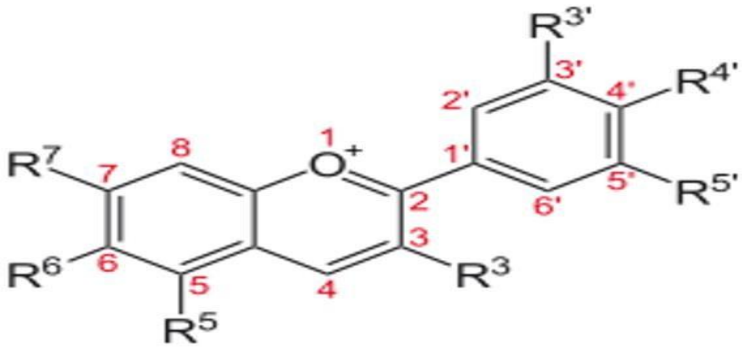


Figure 1: The basic chemical structure of Anthocyanins [4]

Fossen *et al* [5] reported that anthocyanin molecules would change their colour depending upon the pH of their environment. Fossen *et al* [5] added that anthocyanin turns red – pink in acids (pH 1 – 6), reddish – purple in neutral solutions (pH 7) and green in alkaline or basic solutions (pH 8 – 14). Thus this may serve as a pH indicator.

Caesalpinia pulcherrima trees have in this part of the world been at times considered as sources of wastes and are nuisance to the environment as they shed off leaves and flowers which litter our environment. Chen *et al* [6] reported that organic or natural indicators are indicators that are obtained from natural occurring substances. Whether petals of *Caesalpinia pulcherrima* flowers contain organic indicator (s) or not would be confirmed in the course of this research work.

Reagent indicators are substances that give a visible sign, usually by a colour change in the presence or absence of a threshold concentration of a chemical species, such as an acid or alkali in a solution [7]. Indicators are added in small quantities to a solution to determine the acidity of the solution. They reveal through characteristic colour changes, the degree of acidity or alkalinity of solutions. Indicators are weak organic acids or bases that exist in more than one structural form (tautomers) of which at least one form is coloured [8]. They change colours depending on the acidity or alkalinity of the solution. In acid-base titrations, indicators are used to determine the end point (equivalence point). Indicators show sharp colour changes with respect to change in pH. Commonly used indicators for acid base titrations are synthetic [8]. Each indicator exhibits a different range of colours at different pH levels [9]. They are found to possess hazardous effect in human body and pollute the environment [10]. Indicators are classified into two types namely: (i) organic which are either natural or synthetic indicators or (ii) inorganic indicators [11]. Organic natural indicators are indicators that are obtained from natural occurring substances, examples of which are: litmus, turmeric and China rose [6]. Inorganic indicators are indicators that are made in the laboratory, examples of which are phenolphthalein, methyl orange and methyl yellow [12]. Like most indicators, methyl yellow is visible even if its concentration is as low as a few parts per million parts of solution used. At such low concentration, indicators do not have any influence on the conditions for which they are recommended. The common application of indicators is the detection of end points of titration [12]. The colour of an indicator alters when the acidity or the oxidizing strength of the solution or the concentration of a certain chemical species reaches a critical range of values. Indicators are therefore classified as acid-base, oxidation - reaction or specific-substance indicators [13].

Each of these indicators thus has a relatively narrow transition range and each is capable of giving a sensitive sharp indication of the completion of a reaction, that is, at the end point [14]. Although the visible change of the indicator is usually a colour change, in some cases, it is a formation of disappearance of turbidity [14]. If for example a soluble silver

salt is added to a solution of cyanide containing a trace of iodide, the solution remains clear until all the cyanide has reacted to form the soluble silver cyanide complex ion [15]. Upon the addition of silver, the solution becomes turbid because insoluble silver iodide forms. Iodide is therefore an indicator for excess silver ion in this reaction [15].

The aim of this study is to prepare indicator papers from the extract of petals of *Caesalpinia pulcherrima* flowers. Efforts have been made in preparation of *Caesalpinia pulcherrima* solutions for titrimetric analysis. The specific objectives of this study include extraction of colouring matter (dye) from petals of *Caesalpinia pulcherrima* flowers; preparation of indicator solutions using extract from the petals, stripping and sewing of stripped papers, preparation of *Caesalpinia pulcherrima* indicator papers using the extract from petals and validation of prepared indicators compared to litmus paper (control).

MATERIALS AND METHODS

Assorted glass wares, needles, reddish pink and light green threads, scissors - all bought from tailoring accessories vendors were used. Others are A4 papers, construction papers, weighing balance, wash-bottle, blue and red litmus papers as control litmus papers (LP). pH meter (Mettler Toledo) and oven (Model and Serial N0: JS760SL1SS and BD123456A), were the instruments used.

Reagents

The following analytical grade reagents purchased from British Drug House (BDH – UK) were used: Hydrochloric acid (HCI) and Sodium hydroxide (NaOH).

Collection of Materials and Sample Preparation

This was done in line with the procedures reported by Dallatu and Okorafor [16]. About 1 kg petals of *Caesalpinia pulcherrima* flowers were collected into a labeled, washed and rinsed plastic container and transported to laboratory for analysis. Unwanted materials like insect, grasses, leaves, and dried leaves were removed from the samples. About 500 g petals of *Caesalpinia pulcherrima* flowers were blended, sieved into a beaker and filtered. Its colour and pH were noted. Half of the filtrate was alkalized with drops of 1M NaOH. Its colour change and pH were noted. This resulted to a light-green alkalized, and reddish-pink acidic light green alkalized petals of *Caesalpinia pulcherrima* flowers extract solutions (Plates 2a and b) and their pH measured.

Plate 2: (a) Petals of *Caesalpinia pulcherrima* Alkalized Dye Solution and (b) Petals of *Caesalpinia pulcherrima* Acidic Dye Solution

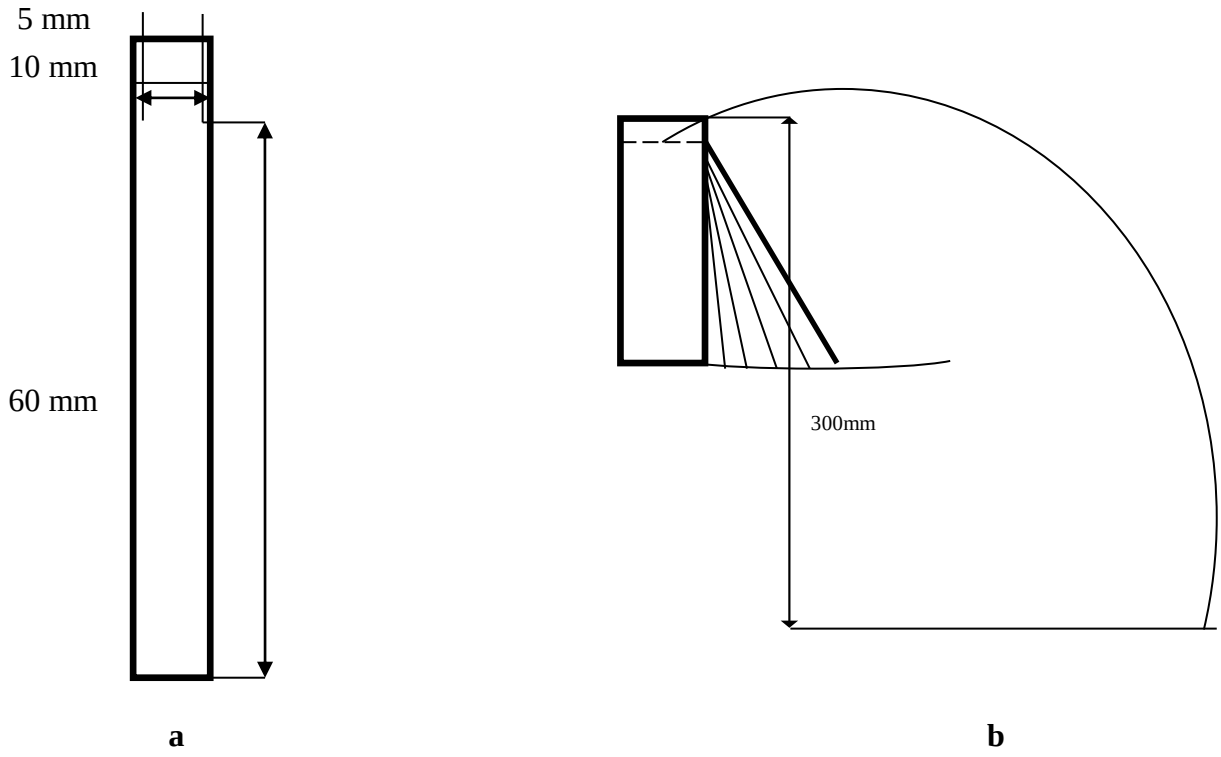
Moisture Content Determination of Petals

Moisture content in triplicates of petals of *Caesalpinia pulcherrima* flowers was determined according to the procedures reported by Onwuka [17]. Equation 1 is used to calculate the percent moisture content. The moisture content results are shown in Table 1

$$\%\text{Moisture content} = \frac{Mass\ of\ moisture}{Mass\ of\ sample} \times 100 \quad (1)$$

Stripping and Sewing of Papers

This was done in line with the method reported by Dallatu and Okorafor [16]. Figures 3a and b show a strip and sown bunch of strips of papers.



A stripped paper

Bunch of six Paper sown Stripped

Figure 2: A Stripped and Bunch of Sown Stripped Papers

Preparation of Reddish Pink and Light Green Petals of *Caesalpinia pulcherrima* Flowers Extract Indicator Papers

These were done by adopting the procedures used by Dallatu and Okorafor [16]. Plates 3a and b show prepared light green and reddish pink *Caesalpinia pulcherrima* indicator papers.

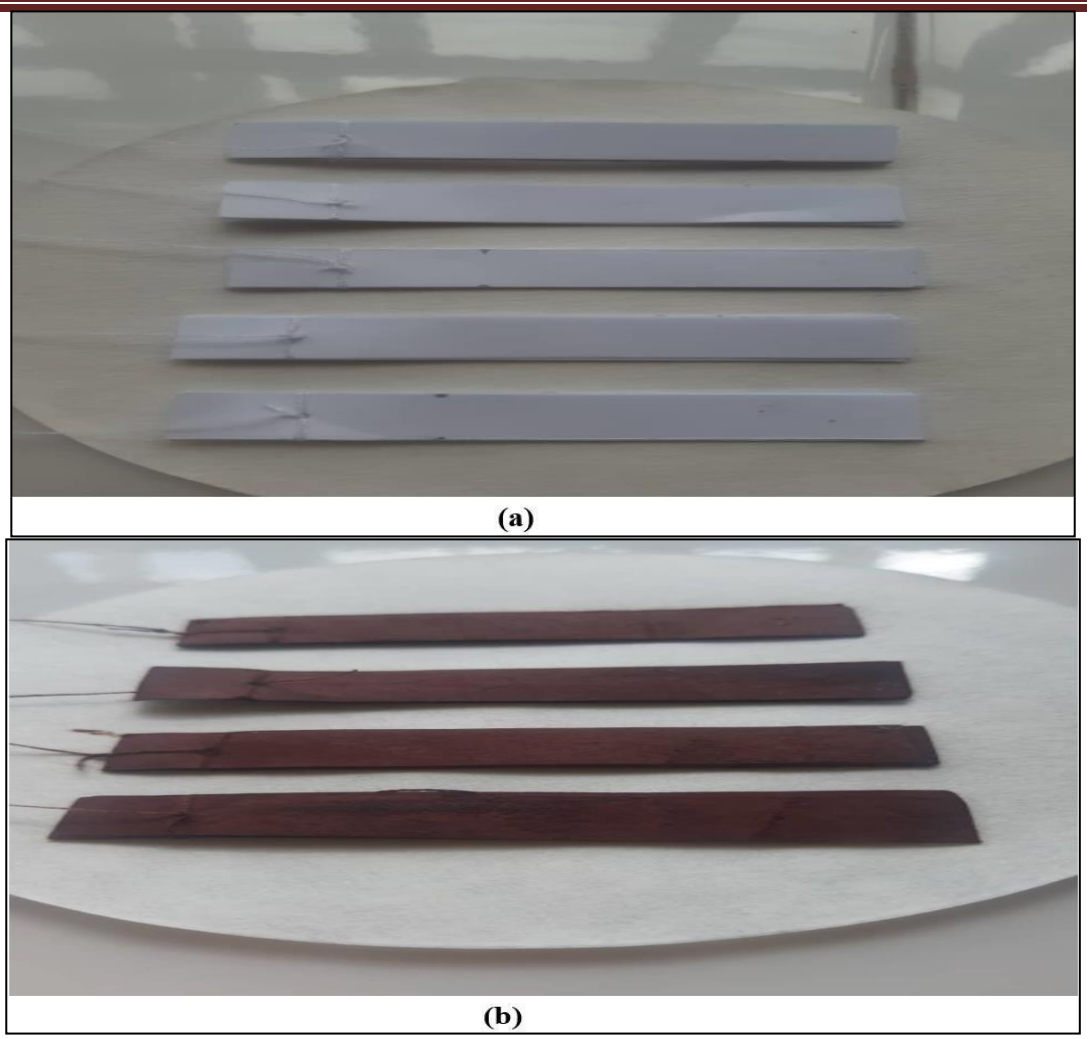


Plate 3: (a) Prepared light green and (b) Reddish pink *Caesalpinia pulcherrima* Indicator papers.

Confirmatory Tests of the Prepared Reddish Pink and Light Green Indicator Papers

Pieces of the reddish pink and light green *Caesalpinia pulcherrima* indicator papers were dipped into 0.2 M HCl and 0.2 M NaOH separately in line with the procedures used by Dallatu and Okorafor [16]. Results of these tests are shown in Table 2

Validation (Performance Analysis) of Prepared *Caesalpinia pulcherrima* Papers

This was done according to the method reported by Dallatu and Okorafor [16]. HCl (1 M) and NaOH were prepared. About 50 cm^3 of each was dispensed into ten 100 cm^3 beakers respectively. A page of standard red litmus paper was used to test the first beaker's acid solution. It was removed and used to test the first beaker's alkaline solution. This was continued until the litmus paper (faded) failed to function or perform as red litmus paper. The number of times for its good performance was recorded. A page of the prepared reddish pink *Caesalpinia pulcherrima* indicator paper was validated using the same procedure. The above

procedure was repeated using standard blue litmus and the prepared light green *Caesalpinia pulcherrima* indicator paper and, data obtained were recorded as such.

The formula,

$$\%\, Efficiency = \frac{Number\ of\ times\ (C.pulcherrima) paper\ functione}{Number\ of\ times\ the\ standard\ Litmus\ paper\ functioned} \times 100$$

was used to measured performance of the prepared *Caesalpinia pulcherrima* indicator paper.

Construction of Protective Packets and Packaging

This was done by adopting the method reported by Dallatu and Okorafor [16]. Packets for reddish pink *Caesalpinia pulcherrima* indicator papers were constructed from reddish pink cardboard papers while those for light green *Caesalpinia pulcherrima* indicator papers were made from light green cardboard papers (Figure 3). Four bunches of reddish pink and light green *Caesalpinia pulcherrima* indicator papers were packed into the packets according to the colours and labels on the packets.

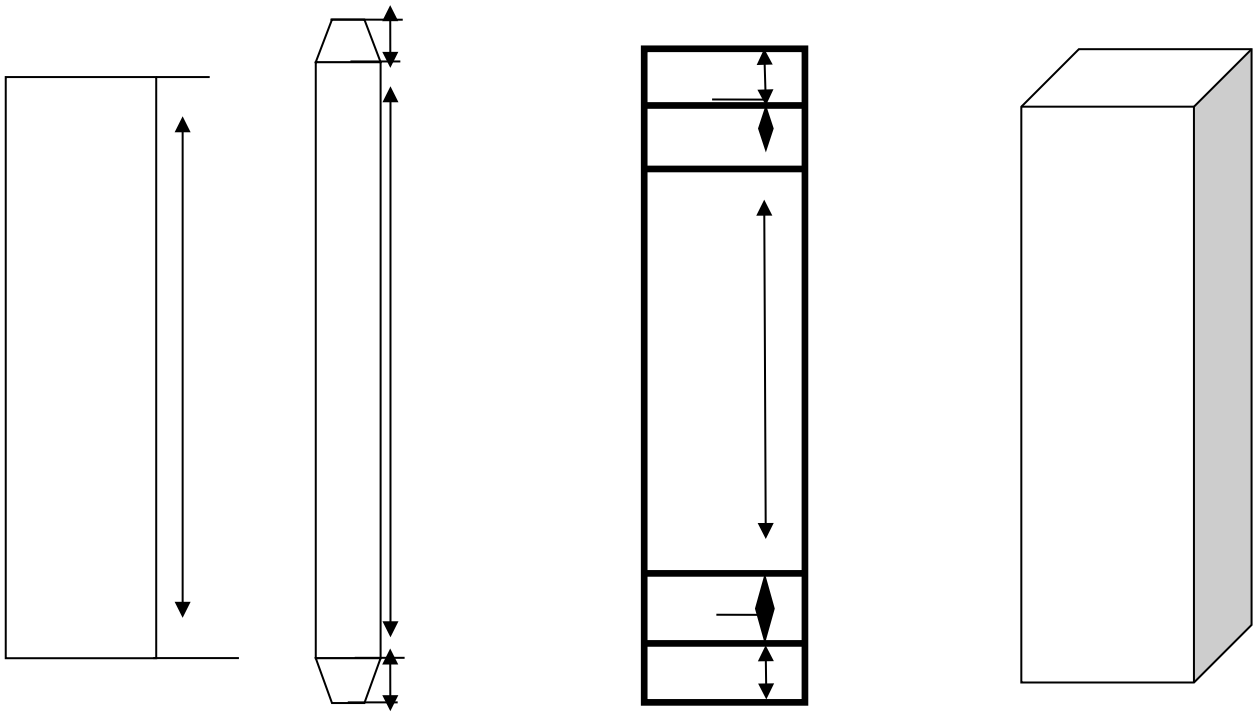


Figure 3: Designed and Constructed Package for *Caesalpinia pulcherrima* Papers

RESULTS AND DISCUSSION

Tables 1 and 2 show moisture content of petals of *Caesalpinia pulcherrima* flowers and confirmatory test of the prepared *Caesalpinia pulcherrima* indicator papers respectively. The pH of the *Caesalpinia pulcherrima* reddish pink indicator solution was 4.50, that of the light green *Caesalpinia pulcherrima* solution was 9.25.

Table 1: Percentage Moisture Content of Petals of *Caesalpinia pulcherrima* Flowers

Sample	Moisture content (%)			
	1st	2nd	3rd	Mean ± SD
C.pulcherrima	66.00	66.01	65.98	66.00 ± 0.118

Table 2: Confirmation of the reddish Pink and Light Green *Caesalpinia pulcherrima* Indicator Papers

Indicator	Acid	Base
Reddish pink paper	Reddish pink	Light green
Light green paper	Reddish pink	Light green

Effects of 0.2 M HCl and 0.2 M NaOH on the prepared reddish pink of *Caesalpinia pulcherrima* papers: retaining its reddish - pink colour in 0.2 M HCl and turning light green in 0.2 M NaOH confirmed the reddish - pink paper as reddish-pink *Caesalpinia pulcherrima* indicator. The prepared light - green *Caesalpinia pulcherrima* paper retained its colour in 0.2 M NaOH but turned reddish-pink in 0.2 M HCl confirming the light-green *Caesalpinia pulcherrima* paper as light-green *Caesalpinia pulcherrima* indicator.

In evaluating the performance of the prepared petals of *Caesalpinia pulcherrima* flowers papers in accordance to the method reported by Dallatu and Okorafor [16] the red SLP functioned 420 doublet times (in acid and base) 50 cm^3 solutions while the prepared reddish pink *Caesalpinia pulcherrima* paper functioned 400 times. The blue SLP functioned 660 doublet times while, the prepared light green *Caesalpinia pulcherrima* paper functioned 220 times.

Equation 2 was used to determine the efficiency of the prepared *Caesalpinia pulcherrima* papers. The reddish pink *Caesalpinia pulcherrima* papers performed 95.23% $(400\ times_{(prepared)}/420\ times_{(SLP)} \times 100)$. However, the prepared light green *Caesalpinia pulcherrima* papers performed 33.33% $(220\ times_{(prepared)}/660\ times_{(SLP)} \times 100)$.

CONCLUSION

Reddish pink and light green *Caesalpinia pulcherrima* paper indicators were prepared. The prepared reddish pink *Caesalpinia pulcherrima* paper turned light green in alkaline solution and the prepared light green *Caesalpinia pulcherrima* paper turned reddish pink in acidic solutions. The performance of reddish pink *Caesalpinia pulcherrima* papers measured against red SLP (control) was 95.23% while that of the light green *Caesalpinia pulcherrima* papers

measured against blue SLP (control) was 33.33%. This study is so significant, as it would provide locally prepared, cheap and environmentally friendly paper indicators using readily available petals of *Caesalpinia pulcherrima* flowers. These papers could be used in our educational institutions, industries and research centers. . Also, large scale preparation of these papers could reduce importation of litmus papers making them cheap. The expectation is that the *Caesalpinia pulcherrima* papers locally prepared would at long run, be exported and serve as foreign exchange commodity.

REFERENCES

[1] Wiersema, J. H. (2019). GRIN Taxonomy. US National Plant Germplasm System. Checklist dataset. https://doi.org/10.15468/ao14pp accessed via GBIF.org on 2022-08-31.

[2] Counter, S. A. (2006). Amazing mystery: A medicine man understood the secrets of this plant long before we did. How? *Globe Correspondent*, July 2, 2006. http://archive.boston.com/news/education/higher/articles/2006/07/24/amazing_my stery/

[3] Kirwan, G.M. (2008). Aves Brasileiras E Plantas Que as Atraem [Brazilian Birds and Plants that Attract Them].*The Wilson Journal of Ornithology*. 120(4), 923-926.

[4] Prabavathy, N., Shalini, S., Balasundaraprabhu, R., Velauthapillai, D., Prasanna, S., Walke, P. & Muthukumarasamy, N. (2017). Effect of solvents in the extraction and stability of anthocyanin from the petals of Caesalpinia pulcherrima for natural dye sensitized solar cell applications. *Journal of Materials Science: Materials in Electronics*, 28, 9882-9892. Available at: https://doi.org/10.1007/s10854-017-6743-7.

[5] Fossen, T., Cabrita, L. & Andersen, O. M. (1998). Colour and stability of pure anthocyanins influenced by pH including the alkaline region. *Food Chemistry*, 63, 435-440. Available at: https://doi.org/10.1016/s0308-8146(98)00065-x.

[6] Chen, Y., Wang, Z., Zhang, H., Liu, Y., Zhang, S., Meng, Q. & Liu, W. (2018). Isolation of high purity anthocyanin monomers from red cabbage with recycling preparative liquid chromatography and their photostability. *Molecules*, 23, 991, Available at: https://doi.org/10.3390/molecules23050991.

[7] Britannica, The Editors of Encyclopaedia. "chemical indicator". Encyclopedia Britannica, Invalid Date, https://www.britannica.com/science/chemical-indicator. Accessed 2 April 2023.

[8] Abdeldaiem, M. H. (2007). Use of yellow pigment extracted from turmeric (Curcuma longa) rhizomes powder as natural food preservative. *American Journal of Food Science and Technology*, 2, 36-47.

[9] Alghamdi, E. (2013). The intake of red cabbage anthocyanines in icecream.*Life Science Journal*. 9, 2654-2657.

[10] Ahmadiani, N., Robbins, R. J., Collins, T. M. & Giusti, M. M. (2014). Anthocyanins contents, profiles, and color characteristics of red cabbage extracts from different cultivars and maturity stages.*Journal of Agricultural and Food Chemistry*. 62:7524-7531. Available at: https://doi.org/10.1021/jf501991q.

[11] Asghari, G., Mostajeran, A. & Shebli, M. (2010). Curcuminoid and essential oil components of turmeric at different stages of growth cultivated in Iran.*Research in Pharmaceutical Sciences.* 4, 55-61.

[12] Damunupola, D., Weerathilake, W. & Sumanasekara, G. (2014). Evaluation of quality characteristics of goat milk yogurt incorporated with beetroot juice. *International Journal of Scientific and Research Publications.* 4, 1-5.

[13] Dhakal, S., Chao, K., Schmidt, W., Qin, J. & Kim, M. (2005). Evaluation of turmeric powder adulterated with metanil yellow using FT-Raman and FT-IR spectroscopy.*Foods*, 5, 36-50. Available at: https://doi.org/10.3390/foods5020036.

[14] Dave, S., Vijay, S., Keswani, H. & Sharma, S. (2014). Curcumin - a magical medicine: A comprehensive review.*International Ayurvedic Medical Journal.* 5: 458 - 467.

[15] Dimitrovsili, D., Stojanovska, M. C., Simonovska, J. & Doneva-Sapceska, D. (2017). Lactic acid fermentation of cabbage juice by probiotic strain, presented at the III International Congress “Food Technology, Quality and Safety", 67-73

[16] Dallatu, E. & Okorafor, L. (2009). Local Preparation of Blue and Red Litmus Papers. *International Journal of Chemical Sciences.* 2, 228-233.

[17] Onwuka, G. I. (2005). Food analysis and instrumentation: Theory and practice. Napthali Prints, 140-146.