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Dyes extracted from natural sources and some of their applications

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Abstract

In this study, a group of natural dyes were extracted from plants (Such as turmeric, hibiscus, red cabbage, onion peel, pomegranate, And beets). The extracted anthocyanin dye has been used to dye cotton fabrics effectively using Vinegar and salt as a stabilizer. It has been also used as acid–base indicators which were compared with common indicators such as methyl orange and phenolphthalein. The results showed agreement in the extent of colour change. These extracts have also been used to prepare chromatography papers that resemble litmus papers.

Key Words

Anthocyanin dye, natural dyes, Indicators, Acid-Base.

1. Introduction:

In recent years, interest in natural dyes extracted from plants has increased significantly, due to their safe properties that make them safer to use in dyeing processes compared to chemical dyes. Credit for discovering indicator of acid-base goes to the scientist Robert Royal, who noticed the disappearance of the blue colour of the triad plant in hard water when an acid was added to it, and the return of the blue colour when drops of sodium carbonate solution were added (Kolthoff, 1973, P.24A).

Most natural dyes are found largely in plant parts such as flowers, fruits, roots, and leaves, and one of these dyes is anthocyanin, which gives many grains, vegetables, fruits, and flowers colours such as red, blue, violet, and orange (Jackman et al., 1996, P. 244).

Anthocyanin dye is considered a flavonoid compound, and it is a polar molecule that contains glycosyl, methoxyl, carboxyl, and hydroxyl, and is connected to aromatic rings. This dye is easy to extract and separate from various plants because it is more soluble in water than non-polar solvents (Harbome et al., 1988, P.1-20). Anthocyanin dye has several properties, including changing colour based on pH, appearing blue, red and violet in acidic, weak acidic and basic mediums, respectively (Mašović et al., 2003, p.102). This dye is flavourless and odourless (Lebling et al., 2006, p.12-21) and non-toxic, and it can also be used as a food colouring and in cosmetics, and it also has health benefits because it contains antioxidants, anti-cholesterol, and anti-carcinogenic. It also regulates blood sugar levels and maintains body weight, protects nerves and retina, and combats aging (Kohno et al., 2014, P.48-51) (Zhu et al., 2018, P.232-249) (Shen et al., 2016, P.1003-1012) (Tsuda, 2012, P.159-170).

Anthocyanin dyes are characterized by containing two basic groups, which are present in all dyes. One of them is an atomic group associated with colour, known as chromophores, which are colourless, and the other group is known as auxochromes, which can bind the chemical compounds of the dye to tissues, and their function is to enhance, intensify, and deepen the colour. Studies have shown that the containment this dye of these two groups gives it colour stability and preservation properties (Bancroft et al., 2007, P.744) (Brouillard et al., 1993, P.4125-3132) (Kallio et al., 1986, P. 408-410). Natural dyes, including turmeric, have been found and used in the medical field as antioxidants and anti-inflammatory agents (Hernandez et al., 2004, P. 169–174) (Kiuchi et al., 1993, P. 1640-1643) (Osawa et al., 1995, P. 1609–161) (Wuthi-udomler et al., 2000, P. 178-182). It has also been found that turmeric extract has protective activity against many diseases, and it also contains curcumin (Ishita et al., 2004, P. 10-18) (Jin et al., 2000, P. 886–980) (Ruby et al., 1995, P. 79-83).

Betaline is considered one of the most important compounds found in beets and has chemical, biological and chromatographic properties like anthocyanins, which gives beets their red colour and can be extracted from red beets (Hohensinn et al., 2016, P. 5–10). The study found that the best carrier of anthocyanin dyes in red cabbage is dextrin, followed by cellulose and soluble starch, and anthocyanin dyes have a higher colour fastness in their acidic state with a pH ranging from 0.1 to 4.

The aim of this research is to use natural dyes extracted from plants (Such as turmeric, hibiscus, red cabbage, onion peel, pomegranate, and beets) In dyeing fabrics, As acid-base indicators and In forming measuring papers for an acidic-basic character of solutions.

2. The Theoretical Framework

Dyes: A substance that changes the colour of the medium in which it enters and ables to soluble in it. It can be of natural origin (animal, plant, or mineral) (2021، لزول واخرون).

Plant dyes: Natural dyes are considered the first dyes used by humans, and their sources were plant roots or seeds, and some insects were used as animal sources, while mineral sources were natural well water, but they cause a weakness in fibre (2000، إنصاف واخرون**).**

Indicators: They are weak acids or bases that their colour change depending on the type of solution (2018 ،محمد واخرون**).**

Titrations: It is a group of measurement operations that are carried out under specific conditions using measuring devices and tools based on national or international standards that are achieved System

units of the International System of Measurement: These processes determine the accuracy of measuring devices, their suitability for the purpose for which they are used, and the extent of their conformity with the International System of Measurement in accordance with specific international standards, and the characteristics of measuring devices and tools are determined by finding the relationship between the real value and the measured value (2021 ،أحمد واخرون).

End point: It is the point at which the colour of the added indicator changes and reaching it indicates that the reaction has ended (2012 ،عبدالله واخرون).

Equivalent point: At this point, the number of moles of acid is exactly equivalent to the number of moles of base present according to the balanced reaction equation (2012 ،عبدالله واخرون).

3. Methodology:

3.1. Materials

The used plants were turmeric, hibiscus, red cabbage, onion peel, pomegranate ،And beets, Cotton fabrics and chemical indicators such as methyl orange and phenolphthalein.

3.2. Measurements

The research was conducted at the chemical Laboratory, Faculty of education, Ain shams University, using Ph Meter and magnetic stirrer**.**

3.3 Synthesis

3.3.1 Extraction of natural dyes

Steps for preparing the dye (26)

1- The plants were washed with tap water and then with distilled water.

2- The plant we use in the dyeing process was cut into small pieces so that we can measure them in standard cups.

3- Then we bring a pot that can be put on the flame, and we add water to the pot, taking into account that the amount of water is twice the amount of ingredients with which it is dyed, then we put the pot on low heat, and leave it to boil for an hour, until the solids are eliminated, and the dye is kept in the refrigerator until used.

3.3.2 Dyeing cotton fabrics

After completing the previous steps, it is time to dye the fabric, and this is done by placing the wet fabric in the dye and leaving it on low heat until the fabric reaches the desired color.

Stabilizer preparation

After settling on the color of the dye and preparing it, we must prepare a fixative of vinegar and salt for the fabric that we want to dye. This is to fix the dye on the fabric later and is not lost when the fabric is washed.

Fabric washing

After completing the dyeing process comes the final stage, which is washing the fabric, and the fabric must be washed separately after dyeing it, using cold water, and then we leave the dyed fabric to dry completely, and then it is ready for use (https://ar.wikihow.com/%D8%B5%D8%A8%D8%BA-%D8%A7%D9%84%D8%A3%D9%82%D9%85%D8%B4%D8%A9-%D8%A8%D8%A7%D8%B3%D8%AA%D8%AE%D8%AF%D8%A7%D9%85-%D8%A7%D9%84%D8%A8%D9%86%D8%AC%D8%B1**).**

3.3.3 Use of extracted dyes as acid – base indicators and natural indicators

3.3.3.1 Testing the ability of dyes to change color by changing pH values.

Weigh 1 g of the dye resulting from hibiscus in a glass bowl, add 40 ml of distilled water, add 1 molar hydrochloric acid, 1 molar sodium hydroxide, and 1 molar sodium chloride solution, each separately, to obtain different pH values, and the color change of the solution is observed with changes in pH values.

We repeat the previous method on other dyes obtained from turmeric, red cabbage, onion peel, pomegranate, and beets.

3.3.3.2 Comparison of extracted dyes with some acid-base indicators

The extracted dyes have been compared with some available and well-known acid–base indicators, namely phenolphthalein and methyl orange:

A- Comparison of dyes with methyl orange indicator MO: Hydrochloric acid was titrated with a standard initial solution of sodium carbonate of 0.1 molar using two drops of methyl orange indicator, after which the process was repeated using 5 drops of each of the isolated dyes.

B- Comparing the dyes with the phenolphthalein indicator Ph.Ph: Sodium hydroxide was titrated with hydrochloric acid at a concentration of 0.1 molar using two drops of the phenolphthalein indicator, and then the process was repeated using also 5 drops of each of the isolated dyes.

3.3.3.3 Use of dyes in aqueous extract to form acid-base detection paper Solutions.

Mix 15 grams of (turmeric, hibiscus, red cabbage, onion peel, pomegranate, and beets) separately with 100 ml of acetic acid at a concentration of 5%, then leave the mixture for 24 hours, stirring constantly using a magnetic stirrer at room temperature. Then filter the mixture and concentrate it to a volume of 25 ml at a temperature of 50 degrees Celsius. The mixture was then divided into two equal parts:

The first part: Several filter papers are placed, which are designed in the form of rectangles with dimensions of 1× 5 cm, for 40 minutes, after which the papers are dried and left for later use.

The second part: 5 ml of sodium hydroxide at a concentration of 2 molar was added to it. After that, several filter papers of the same dimensions were placed in it and left in it for the same period, after which the papers were dried and left until later use.

4. Results of Research

Anthocyanin dye was extracted from turmeric, hibiscus, red cabbage, onion peel, pomegranate, and beets in this study using water because it does not have any toxic effect, and water does not affect the composition of the dye and can be evaporated at low temperatures without affecting the chemical structure of the extracted dye (Ncube et al., 2008, P. 1797-1806).

The results of the study showed that the natural dye extracted from hibiscus, pomegranate, and onion peel was acidic, with a value of 3, 3.7, and 5, respectively, while the dye of purple cabbage, turmeric, and beets was weakly acidic, as evidenced by their pH measurement, which reached values of 6.6, 6.6, and 6.9, respectively. The color of natural anthocyanins depends on their pH values. This is likely due to the change in the molecular structure of the dye due to the ionic nature of this dye and the effect resulting from the difference in pH values as shown in Figure (1) (Brouillard et al., P.1-40) (Von Elbe et al., 1996, P. 651-722).

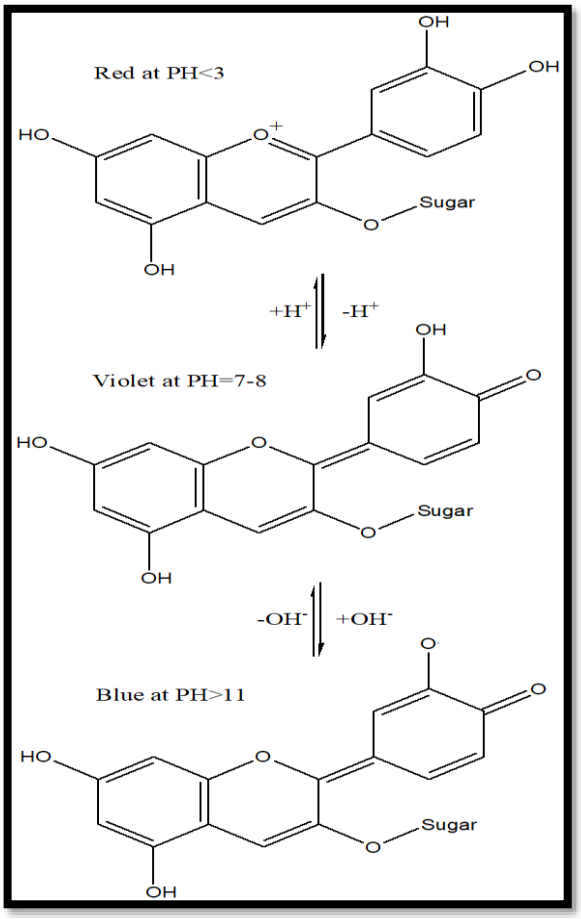

Figure (1) Chemical structure of anthocyanin dye in acidic, neutral, and basic media (Ncube et al., 2008, P. 1797-1806).

4.1 Fabric dyeing

This extracted dye was able to penetrate the cotton tissues, as shown in Figure (2), and the dye was not fixed after washing these tissues with water except when adding vinegar and salt as a stabilizer for the dye. This is due to a complex formation between the dye and the solid, which provides protection for the colour of the dye from decomposition through various decomposition processes (Goodarzian et al., 2010, P. 1387-1389). In other words, this complex prevents the

dissolution of the dye when washing the dyed fabric with water and works to stabilize the colour and consolidate it within the fabric (Jothi, 2008, P. 49-53) (Adeel et al., 2009, P. 3493-3499).

Figure (2) Dyeing cotton fabrics with anthocyanin dye extracted from plants.

Table (1) Colours of dyes in acidic, basic, and neutral mediums.

Plant	Medium	Colour
Turmeric	Acidic Neutral Basic	Yellow Yellow Orange red
Hibiscus	Acidic Neutral Basic	Orange red Pink Olive
Red cabbage	Acidic Neutral Basic	Red Blue Green
Onion peel	Acidic Neutral Basic	Pale red Pale brown Pale brown
Pomegranate	Acidic Neutral Basic	Yellow Pale yellow Burgundy
Beets	Acidic Neutral Basic	Reddish brown Copper Olive

4.2 Use of extracted dyes as acid-base indicators

4.2.1 Testing the colour change of dyes with changing pH values

It is clear from Table (1) that isolated dyes do not have the same color change with changes in pH, as they change in the acidic, basic, and neutral environment (Al-Obaidi, 2012) as shown in Figure (3).

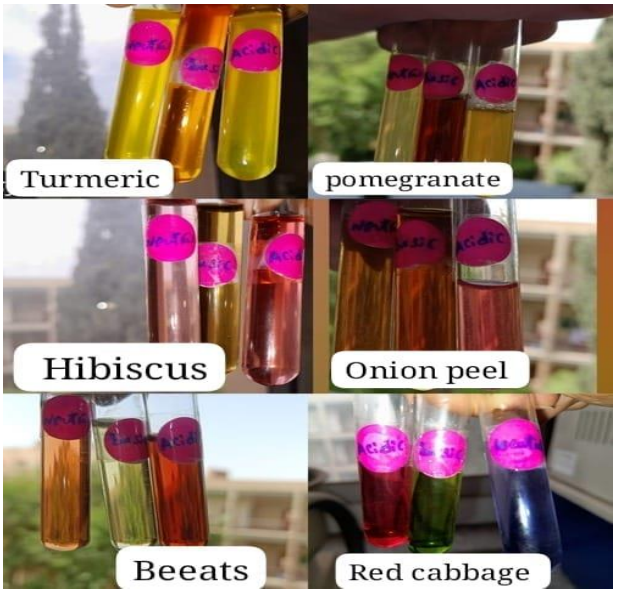

Figure (3) Colour of dyes extracted from plants in acidic, basic, and neutral mediums.

4.2.2 dyes test with some neutralization indicators

When titrating 0.1 molar hydrochloric acid with a primary standard solution of 0.1 molar sodium carbonate using methyl orange indicator and dyes, we found agreement in the volume of acid used. The average volume for methyl orange was 6 ml and for the dyes extracted ranged between 5.7-6.2. When using a standard acid with sodium hydroxide of 0.1 molar using the phenolphthalein indicator, we also found volume compatibility. The average volume using phenolphthalein was 6 ml and ranged between 5.9-6.2 ml using the extracted dyes. Therefore, it can be recommended that these extracted dyes be used as acid-base indicators successfully.

4.2.3 Results of using extracted dyes to form acidic-basic detection papers

The test was performed on filter papers treated with plant extracts. It was observed that all

papers that were immersed until saturated with the extracts, for example the hibiscus plant Figure (4), acquired a color like the dye isolated from the plants used. A change in color was also observed in the acidic and basic solution. Through this experiment, papers like litmus papers were obtained, which are considered effective in determining the acidic and basic nature of solutions when immersed in those solutions. This method has been used according to the literature (Hammouri et al., 2001, P.173-183) (2019 عمر واخرون،).

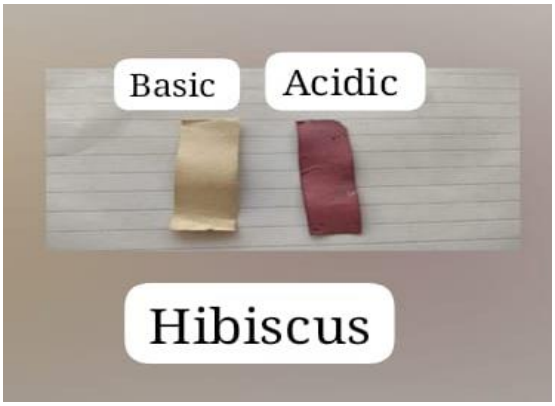

Figure (4) Acidic-basic detection papers using dye extracted from hibiscus.

6. Conclusion

Anthocyanin dye is characterized by its ease of extraction from plants and its good concentration, in addition to its low cost and the availability of proven substances at low cost. Finally, the success of its use in dyeing cotton fabrics and its use as acid–base indicators will encourage in the future its use in the educational and commercial fields, rather than industrial dyes that pose a public health risk.

Recommendations

1. Obtaining the extracted dye by the separation funnel method and purifying it using the thin layer chromatography method and high-performance liquid chromatography and using chemical dyes as standard solutions.
2. Verify the identity of the extracted dye by determining its melting point and boiling point, in addition to determining its composition using an IR infrared device and drying it with a drying device to use it as a powder with a studied concentration.
3. Applying them to some medical conditions as they are antioxidant substances.

Future research in the field studied:

Textile printing: Dyes are used to create complex designs on fabrics through a process called screen printing.
Medical applications: Some dyes are used in medical procedures as contrast agents to improve the vision of internal body structures in medical imaging tests such as X-rays, CT scans, and MRI.

Research and Analysis: Dyes are used in research and analysis including the study of chemical biological processes, water quality testing, and environmental monitoring.
Food colouring: Dyes are used to add colour to food products, drinks, and sweets as an alternative to artificial colour additives.
Inks: Dyes are used in the production of printing, drawing, and writing inks.
Paints: Dyes can be used to create pigments for paints and coatings that can be used.

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