NATURAL INDICATOR: USE OF RED CABBAGE JUICE AS AN INDICATOR IN FOOD, COSMETIC INDUSTRY AND EDUCATIONAL LABORATORIES

Pardayev Ulug‘bek Xayrullo o‘g‘li
E-mail: pardayevulug‘bek125@gmail.com

Xoliqulov Hamro Jasur o‘g‘li
E-mail: hamroxoliqulov5@gmail.com

Tilyabov Maxsudjon Umurzokovich
E-mail: tilyabov_maq@mail.ru
Organization: 1 - Uzbekistan-Finland Pedagogical Institute

ABSTRACT

Red cabbage juice has long been known to be a natural indicator. This means that it can be used to determine the pH value of a substance by changing color in response to acidity or alkalinity. In this article, we explore the use of red cabbage juice as an indicator in the food, cosmetic industry, and educational laboratories.

Keywords: natural indicator, anthocyanin, red cabbage, laboratory, equilibrium state, alkaline environment, acidic environment, neutral environment, pigment, cosmetics and food industry

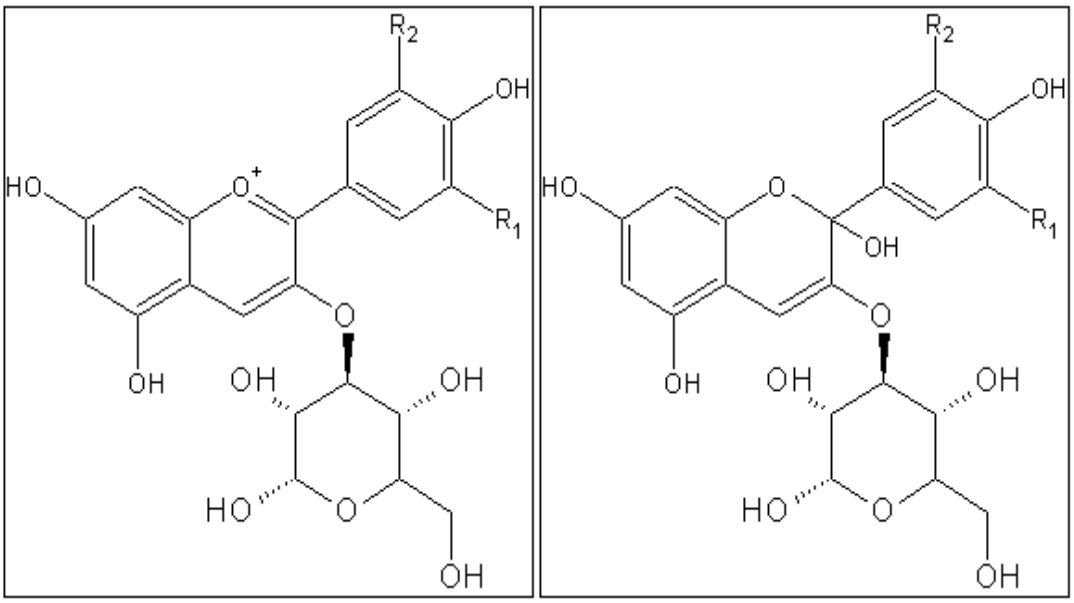
Procedure of experiment:

1. Grate the red cabbage into small pieces and place them into the pot. Add water until the cabbage is covered with it.
2. Boil the cabbage for 20 to 30 minutes until the liquid has a dark purplish colour.
3. Decant the fluid into a glass or a jar through a strainer to remove the cabbage. Do not throw away the cabbage; you can still eat it.
4. Make some test solutions which are either acidic or basic. Also have a "test" solution; water should be fine (although water is slightly acidic.)

5. Add a few drops of the cabbage juice to your solutions and write down the colour changes. You now have your own pH-indicator!

Red cabbage contains pigments called anthocyanins. These pigments give the purplish colour. On the right side is the general chemical structure of anthocyanins. R_1 and R_2 can be different chains, like H, OH and OMe.

Figure 1:



The anthocyanin present in red cabbage is cyaniclin. Some food sources containing anthocyanins are shown below. In an acidic environment, the left form is the more abundant, whereas in a basic environment, more of the right form is present. Both molecules have a different colour, hence we see a change in colour. For most pH indicators, the compound acquires a proton at low pH (lots of H^+) but looses it at higher pH. This seemingly minor alteration is sufficient to alter the wavelengths of light reflected by the compound, thus creating the color change with respect to pH. Anthocyanins behave somewhat inversely in that the pigments "gain" an OH^- at basic pH, but loose it at acidic pH.

An acidic solution contains an excess of protons or H^+. pH is a measure of how ‘acidic’ a solution is. The lower the pH, the more acidic the solution. In chemical terms, pH means "the negative log of the concentration of protons" in solution. Chemistry students should recognize this as pH = -log[H^+]. If the concentration of H^+ is 0.01M, the pH will be: -log[0.01] = -log[10^{-2}] = -(-2) = 2 (which is very acidic!).

"Neutral" solutions (water, e.g.) have a pH of 7. This number coicides with the amount of H^+ naturally formed in water from the equilibrium reaction:

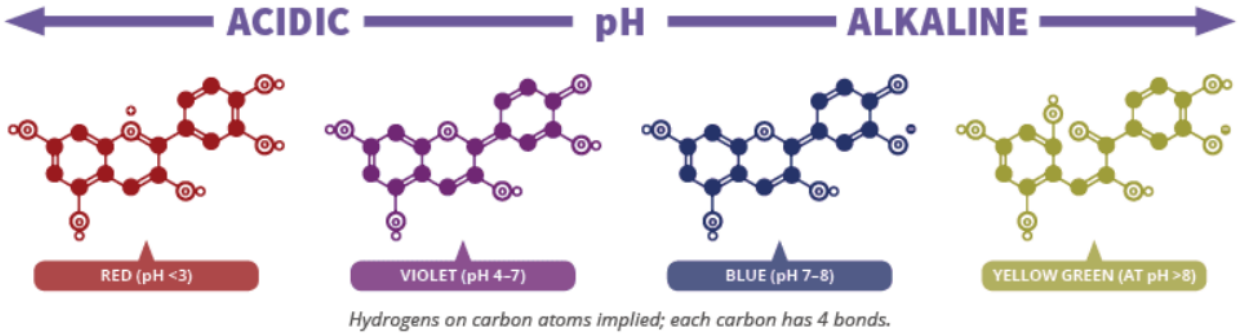
H_2O <--> H^+ + OH^- (H^+ experimentally known to be ~10^{-7}M; OH^- is also the same concentration). "Basic" solutions have a pH greater than 7 - meaning they have less free H^+ than that of neutral water.

Red cabbage as a natural indicator:

Red cabbage contains a pigment called anthocyanin, which gives it its color. This pigment changes color depending on the acidity or alkalinity of the environment. When the pigment is in an acidic solution, it appears red. In basic environment, it changes to blue-green color. Retains purple color in neutral solution.

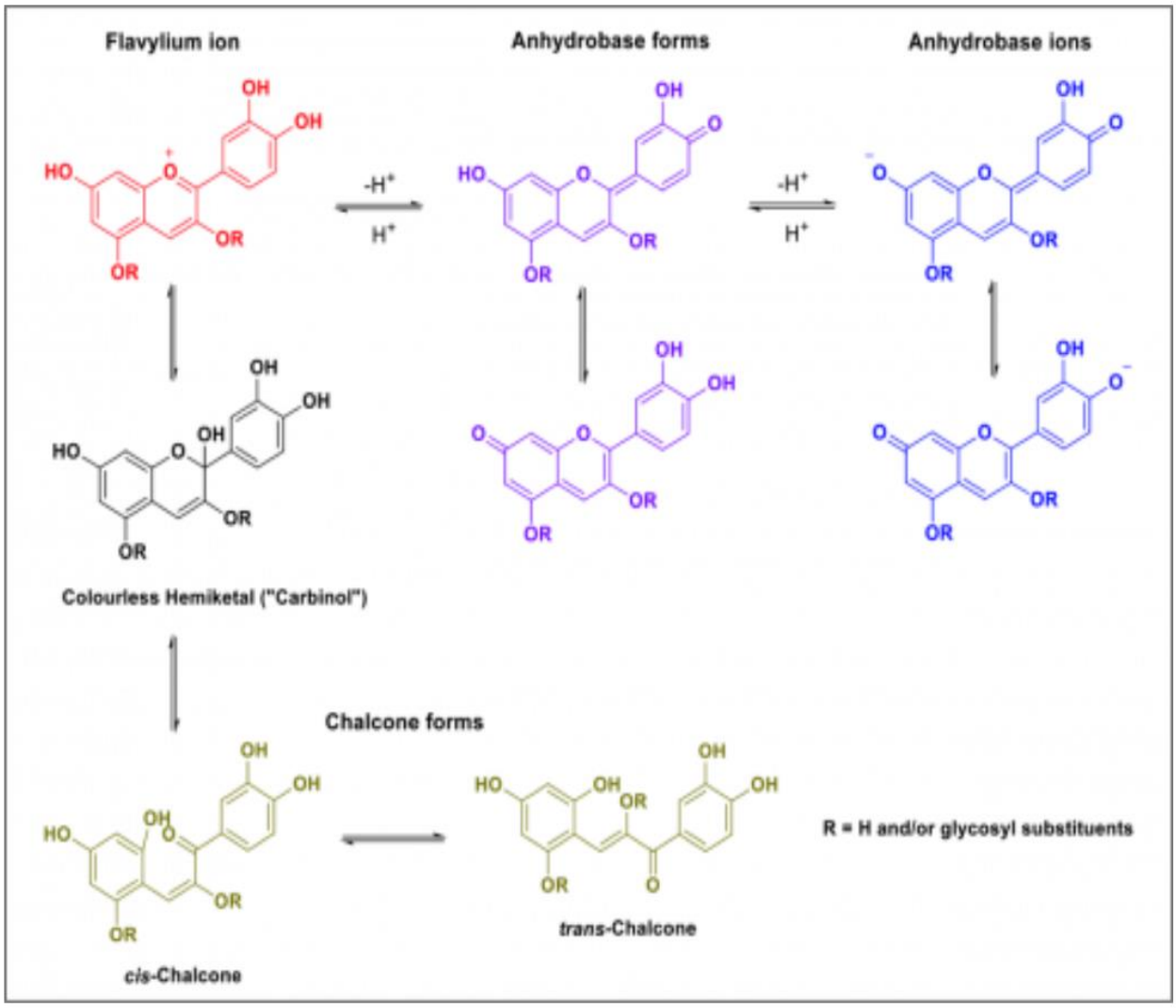
Figure 2:

Color of red cabbage juice pH values



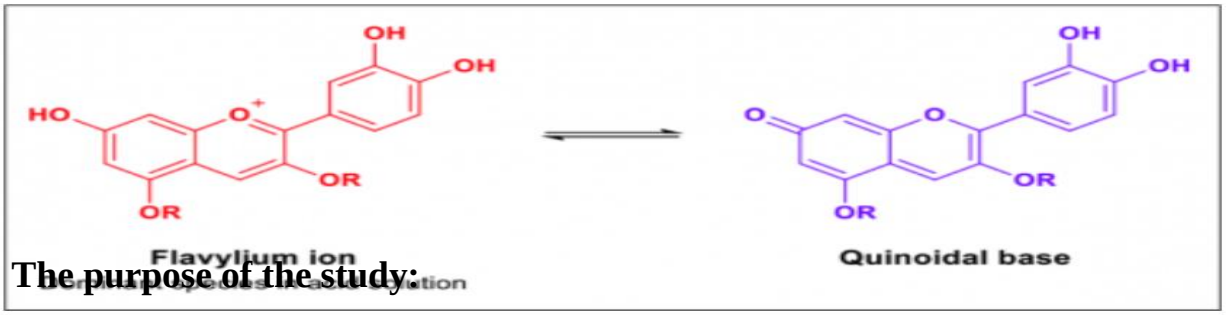
The composition of aqueous solutions of anthocyanins in red cabbage juice is controlled by a complex series of equilibria due to pH variation (Scheme 1). The flavyl ion form is dominant at low pH, and it rapidly equilibrates with the quinoidal base form around pH 4–5 (the quinoid form becomes more abundant as pH increases). The colorless

hemiketal (“carbinol”) and green/yellow cis-chalcone and trans-chalcone equilibria become prominent with increasing pH.



Scheme 1 - *Key anthocyanidin pH dependent aglycone forms in aqueous solution.*

As described in the introduction, the composition of aqueous solutions of anthocyanins is complicated as the pH is varied (scheme 1). It is therefore difficult to say for certain which processes are responsible for all of the color changes observed, however, we suggest here some possibilities based on our observations. Although the flavylium form is dominant at low pH, it is in rapid equilibrium with the quinoidal base form up to pH 4-5 (equation 1).



The purpose of the study:

Equation 1 - Flavylium ion/quinoidal base equilibrium equation

Researchers use red cabbage as a natural indicator for a variety of reasons. One of the main reasons for this is that it is cheap and easy to prepare. Unlike synthetic indicators, which can be expensive and difficult to find, red cabbage is readily available at any grocery store. It consists in studying the methods of using safe, low-cost, quickly prepared natural indicators and improving their widespread use in food and industrial laboratories.

Another reason is that it is a safe and non-toxic alternative to synthetic indicators. Synthetic indicators can harm the environment and people if not used properly. Red cabbage is a natural and safe indicator.

Red cabbage juice can also be used to determine acid and basic properties in educational laboratories. By experimenting with red cabbage as a natural indicator, students can learn about pH, acidity, and basicity in a fun and interactive way.

Use in the Food Industry:

The food industry uses red cabbage juice as an indicator to determine the pH of different foods. This can be useful in determining the freshness of certain foods, as well as the effectiveness of preservatives. For example, if the pH of a food product is too high, it can spoil quickly. By measuring the pH with red cabbage juice, food manufacturers can ensure that their products are safe for consumption.

Use in the Cosmetic Industry:

The cosmetic industry also uses red cabbage juice as an indicator to determine the pH of their products. This is important because the pH of a cosmetic product can affect its effectiveness and safety. For example, if the pH of a shampoo is too high, it can cause damage to the hair and scalp. By using red cabbage juice to test the pH of their products, cosmetic companies can ensure that their products are safe and effective for consumers.

Use in Educational Laboratories:

Red cabbage juice is also a popular indicator in educational laboratories. It is a safe and easy-to-use alternative to synthetic indicators like phenolphthalein. Students can use red cabbage juice to test the pH of different substances in the lab, and observe the color changes that occur. This can help them better understand the concept of pH and its importance in different applications.

CONCLUSION

In conclusion, red cabbage juice is a versatile and natural indicator that has many applications in industry and education. Its pH-sensitive pigment, anthocyanin, makes it a useful tool for determining the acidity or alkalinity of different substances. From testing the freshness of food to ensuring the safety of cosmetic products, red cabbage juice is a valuable resource for many industries. Additionally, its use in educational laboratories can help students better understand the science behind pH and its applications.

REFERENCES:

1. Pardayev.U.X, Tilyabov.M.U, Egamberdiyeva.D.M, “Исползования в технических и в учебнsх лабораториях на основе естественных индикаторов: настойка чая, соков граната, краснокочанной капусты и морковный” PROGRESSIVE RESEARCH IN THE MODEN WORLD 31.03.2023, PAGES:170-173
2. Pardayev.U.X, Tilyabov.M.U, Yo‘ldoshev.Sh.E, “Indikatorlarning ayrim xossalari(molekulyar tarkibi, umumiy kelib chiqishi va ishlash mexanizmlariga ko‘ra klassifikatsiyalash” ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ 03.05.2023, PAGES:403-407
3. Shakhashiri, B.Z. 1983, Chemical Demonstrations – A Handbook for Teachers of Chemistry, vol. 3 pp. 4.6. Smellie, I. A.; Patterson, I. L. J.; Allan, A.; Worley B., Aqueous red cabbage extracts: More than just a pH indicator, Chemical Education Xchange (chemedx.org). (accessed 28th November 2020)
4. Э. Бишоп. “ИНДИКАТОРЫ”. Москва -1976.
5. Fortman, J. J.; Stubbs, K. M. Demonstrations with red cabbage indicator. JChemEd, 1992
6. J. Mendoza, N. Basilo, V. de Freitas and F. Pina., New procedure to calculate all equilibrium constants in flavylium compounds: Application to the copigmentation of anthocyanins. ACS Omega, 2019, 4, 12058-12070.

7. Г.И. Штремплер. “Домашняя лаборатория (Химия на досуге)” Спб:Питер–1996.
8. F. Pina, M. J. Melo, C. A. T. Laia, A. J. Parola, J. C. Lima, Chemistry and applications of flavylium compounds: a handful of colours. Chem. Soc. Rev., 2012, 41, 869-908.
9. Proceedings of Global Technovation 2nd International “Multidisciplinary Scientific Conference” Hosted from London, U.K. Rahmonova D.R December 28th, 2020
10. Berké, B.; Chèze, C.; Vercauteren, J.; Deffieux, G. Bisulfite addition to anthocyanins: revisited structures of colourless adducts. Tetrahedron Lett., 1998, 39, 5771-5774.
11. B. S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell and A. I. Vogel, Vogel’s Textbook of Practical Organic Chemistry, Longman Scientific & Technical, Harlow, 5th Edition, 1989, ch. 9.5, pp. 1220.
12. T. D. Stewart, L. H. Donally, The Aldehyde bisulfite compounds. I. the rate of dissociation of benzaldehyde sodium bisulfite as measured by its first order reaction with iodine. J. Am. Chem. Soc., 1932, 54, 2333-2340.
13. O. Dangles, J-A. Fenger, The Chemical reactivity of anthocyanins and its consequences in food science and nutrition, Molecules. 2018, 23, 1970.
14. И.Л.Кнунянц “Химическая энциклопедия” В 5-х томах. Москва-1988.
15. https://www.chemedx.org/article/disappearing-rainbow-demonstration-colourful-variant-using-red-cabbage-extracts
16. https://scitechconnect.elsevier.com/making-red-cabbage-ph-indicator-method-chemistry/
17. https://www.acs.org/education/outreach/activities/red-cabbage-indicator.html