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🌐 Preparing an Eco-Friendly pH Indicator Using Red Cabbage Extract suitable for Low-Budget labs

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We use this protocol and it's working

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Abstract

This protocol outlines the preparation of a natural, eco-friendly pH indicator using red cabbage extract. The anthocyanins in red cabbage change color across the pH spectrum, making it an effective, low-cost, and environmentally safe alternative to synthetic chemical indicators. The addition of garlic extract as a natural preservative extends the shelf life of the indicator. This protocol is designed for laboratory or educational settings, requiring minimal equipment and ensuring accessibility. It Generally provides a frugal alternative to low-income Labs in developing countries to measure PH to conduct research in various fields, Biotechnology included.

we call our final product in this protocol: The Syrian PH indicator kit.

Objective: To prepare a natural pH indicator from red cabbage extract that is safe, cost-effective, and capable of visually indicating pH changes from 1 to 14 (relatively).



Materials

Reagents

- **Red cabbage (300 g, fresh)**
- **Distilled water (200 mL, boiling)**
- **Garlic cloves (2 medium-sized cloves, for natural preservation)**
- **PH buffer solutions (pH 1 to 14, standard laboratory-grade solutions, 1000 μ L per test)**

Equipment

- Laboratory thermometer
- Grater (manual or food processor)
- Glass beaker (500 mL capacity)
- Fine mesh strainer
- Cheesecloth or muslin cloth
- Micropipette (100–1000 μ L range)
- Test tubes (14, glass, 15 mL capacity)
- Test tube rack
- Glass stirring rod
- Hot plate or water bath (for boiling water)
- A4 paper and laminator (for creating a color reference chart)
- Dropper bottle (for storing and dispensing the indicator)
- Safety equipment (gloves, lab coat, safety goggles)

Safety warnings

- ! • Wear gloves, a lab coat, and safety goggles when handling boiling water and preparing solutions.
- Ensure proper ventilation when boiling water to avoid steam burns.
- Handle garlic with care to avoid skin irritation; wash hands thoroughly after preparation.
- Dispose of biological waste (cabbage and garlic residues) according to local regulations.

Protocol to make PH indicator

45m

1 Step 1: Prepare the Laboratory Environment

1. Measure and record the ambient laboratory temperature using a laboratory thermometer. Ensure it is approximately 20°C for consistent results.
2. Clean and dry all equipment to avoid contamination.
3. Set up a clean workspace with all materials and equipment within reach.

2 Step 2: Prepare Red Cabbage

10m

1. Select 300 g of fresh red cabbage. Remove any wilted outer leaves.
2. Using a grater or food processor, finely grate the cabbage to maximize surface area for pigment extraction. ⌚ 00:10:00
3. Place the grated cabbage into a 500 mL glass beaker.



300 grams of red cabbage

3 Step 3: Extract Pigments

25m

1. Boil 200 mL of distilled water using a hot plate or water bath. ⌚ 00:15:00
 2. Carefully pour the boiling water over the grated cabbage in the beaker.
 3. Stir gently with a glass stirring rod to ensure even mixing.
 4. Allow the mixture to steep for ⌚ 00:10:00 to extract the anthocyanin pigments.
- The solution will turn a deep purple color.



soaking red cabbage in hot water

4 **Step 4: Filter the Extract**

1. Place a fine mesh strainer over a clean glass beaker.
2. Pour the cabbage mixture through the strainer to separate the liquid extract from the solid residue.
3. For a clearer solution, filter the liquid a second time through a cheesecloth or muslin cloth placed in the strainer.
4. Collect the filtered extract in a clean beaker and discard the solid cabbage residue responsibly.



filtration of the red cabbage extract

5 **Step 5: Add Natural Preservative**

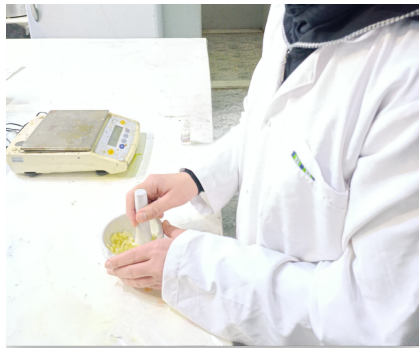
 00:10:00

10m

1. Peel and finely crush two garlic cloves using a mortar and pestle or a garlic press.
2. Wrap the crushed garlic in a small piece of cheesecloth to form a sachet.
3. Squeeze the sachet over the cabbage extract to release garlic juice (approximately

1–2 mL) into the solution.

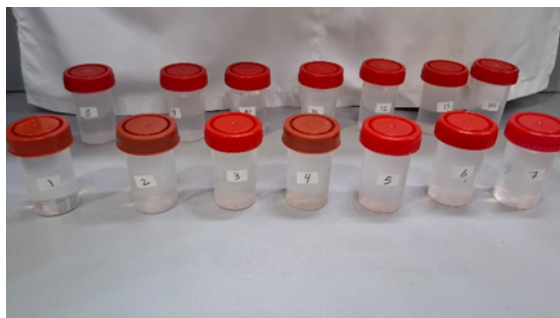
4. Stir the extract gently to mix the garlic juice evenly. This acts as a natural preservative to extend shelf life.



preparing garlic extract for natural preservation

6 Step 6: Prepare pH Test Solutions

1. Label 14 test tubes with pH values from 1 to 14.



solutions with known PH from 1-14 calibrated with PH meter.

2. Using a micropipette, add 1000 μ L of the corresponding pH buffer solution to each test tube.

3. Place the test tubes in a rack for stability.

7 Step 7: Test the Indicator

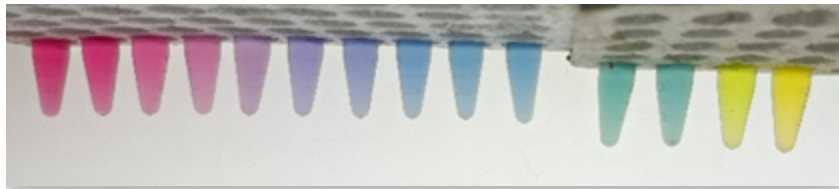
1. Using a micropipette, add 200 μ L of the red cabbage extract to each test tube containing the pH buffer solutions.

2. Gently swirl each test tube to mix the contents thoroughly.

3. Observe and record the color changes in each test tube immediately. The expected color changes are as follows:

o pH 1: Bright red

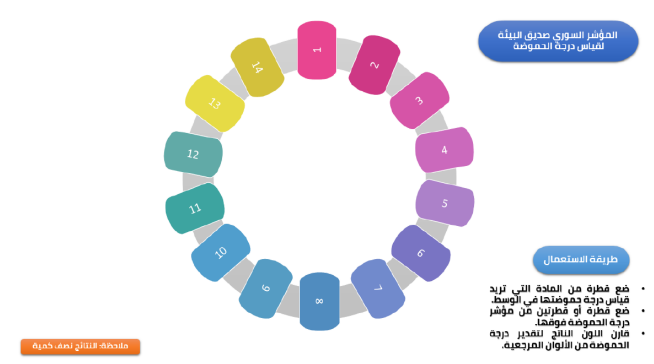
- o pH 2: Red (slightly lighter)
- o pH 3: Dark pink
- o pH 4: Pink with a purple tint
- o pH 5: Vibrant purple
- o pH 6: Dark purple
- o pH 7: Purple transitioning to blue
- o pH 8–10: Blue
- o pH 11: Blue transitioning to green
- o pH 12: Dark green
- o pH 13: Yellow-green
- o pH 14: Bright yellow



PH colors of red cabbage extract from 1 (left) to 14 (right)

8 Step 8: Create a Reference Chart

1. Document the observed colors for each pH value by photographing or manually recording the shades.
2. Print a color reference chart on A4 paper, listing the pH values and corresponding colors. You can use different color detection apps to determine the exact color for each PH.
3. Laminate the chart for durability and future reference.



PH colors chart

9 **Step 9: Store the Indicator**

1. Transfer the remaining red cabbage extract into a clean dropper bottle for easy dispensing.
 2. Store the bottle in a refrigerator at 4°C to maintain stability.
- The garlic extract should help preserve the solution for up to 2–3 weeks.



storing the indicator as a kit

10 **Step 10: Validate the Indicator**

1. To confirm the indicator's reliability, prepare a new set of test tubes with pH buffer solutions (pH 1–14).
2. Add 1–2 drops of the red cabbage extract to each test tube using the dropper bottle.
3. Compare the resulting colors with the laminated reference chart to ensure consistency.
4. Record any deviations and adjust the preparation method if necessary (e.g., check for contamination or improper storage).



measuring a sample using the locally manufactured PH indicator

Expected Results

- 11 The red cabbage extract serves as an effective pH indicator, displaying distinct color changes across the pH range:

- Acidic solutions (pH 1–6): Red to purple hues
- Neutral solution (pH 7): Purple to blue transition
- Basic solutions (pH 8–14): Blue to yellow hues

These color changes are due to the anthocyanin pigments in red cabbage, which respond to hydrogen ion concentration. The indicator is sensitive, cost-effective, and environmentally friendly, making it suitable for educational and laboratory use.

Notes

- **The extract's shelf life may vary depending on storage conditions. If cloudiness or an off-odor develops, discard the solution and prepare a fresh batch.**
- **For more precise pH measurements, combine the indicator with a pH meter for calibration.**
- **The garlic extract is optional but recommended for extended storage. If preservation is not needed, skip Step 5.**
- **Ensure all equipment is thoroughly cleaned to avoid cross-contamination, especially when testing multiple pH solutions.**



Molecular Mechanism of Anthocyanin Color Change

- 12 Anthocyanins, the pigments responsible for the color changes in red cabbage extract, are flavonoids that exhibit pH-dependent structural transformations. In acidic conditions (pH 1–6), anthocyanins predominantly exist in the flavylium cation form, which is red or pink due to its conjugated structure absorbing light in the green spectrum. As the pH increases to neutral (pH 7), the flavylium cation loses a proton, forming a quinonoidal base, which appears purple. In basic conditions (pH 8–14), further deprotonation or hydration of the anthocyanin molecule results in chalcone or carbinol pseudobase forms, leading to blue, green, or yellow hues due to shifts in electron delocalization and light absorption. These reversible structural changes, driven by the protonation state of the molecule, enable anthocyanins to serve as sensitive visual indicators across the pH spectrum.

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