

ACTIVITY TITLE: Culinary Colors – The Chemistry of Natural Food Dyes

Activity code: ncEDE02



 DURATION	90 minutes
 AGE RANGE	11-12 years old
TOPICS	CHEMISTRY ARTS FOOD SCIENCE



Description of the project

In this hands-on, sensory-rich STEAM activity, students will become kitchen chemists and artists as they explore how natural ingredients can be transformed into colorful pH-sensitive dyes.

The goal is to discover the chemical behavior of natural pigments such as those in red cabbage, turmeric, and beetroot when exposed to acids and bases, and to creatively apply them to edible canvases like rice paper or cookies.

Throughout the session, students will investigate how pH influences color reactions, compare solubility properties of different materials, and express their findings artistically by designing vibrant, edible artwork. They will also engage in cultural exploration by examining traditional uses of natural pigments across civilizations such as the Maya and Egyptians.

The activity blends chemistry, food science, and artistic design, fostering inquiry-based learning, cultural awareness, and teamwork in a playful and inclusive environment.

By the end of the session, students will:

- Understand how pH affects natural pigments and observe solubility behaviors.
- Conduct guided experiments using household acids and bases.
- Design and present an original piece of edible art using food-based dyes.
- Reflect on the connection between science, culture, and creative expression.
- Collaborate in rotating team roles to enhance peer learning and inclusion.



Objectives: What will I learn?

- **Understand the pH scale and its influence on natural pigments** by observing color changes during chemical reactions with acids and bases to explain how acidity and alkalinity affect molecular structures in everyday substances.
- **Apply the scientific method** by conducting hands-on experiments using natural pH indicators to develop inquiry and data observation skills through real-world, food-based chemistry.
- **Investigate the cultural and historical significance of natural dyes** by exploring how ancient civilizations used plant-based pigment to foster global awareness and contextual understanding of chemistry through tradition.
- **Design and create an original artistic piece** by using extracted natural dyes to express chemical concepts through visual storytelling and enhance their creativity and aesthetic reasoning.
- **Collaborate in diverse team roles** to plan, experiment, and reflect on their outcomes to promote inclusive learning, critical thinking, and communication skills.



Materials: What do I need?

1. **Provided by the teacher/institution:**
 - Red cabbage, lemon, baking soda, vinegar, turmeric, beetroot
 - Water, paper, brushes, gloves, apron, jars, droppers, coffee filters
 - Plastic trays, table covers, cardboard
 - Computers
2. **Provided by students:**
 - Notebook, markers, sketch paper, aprons (optional)
3. **Downloadable resources:**
 - [Pigment Chemistry Quick Guide](#)
 - [Kitchen Lab Safety Sheet](#)
 - [Visuals of ancient pigment](#)
 - [Cultural Pigment Card](#)
 - [Analysis Chart](#)



Previous preparation

- **Introduce Purpose and Cultural Context**

Start by introducing the purpose of the activity: to explore the intersection of chemistry, food science, and art through natural pigments. Present visuals of ancient pigment use from cultures like

the Maya and Egyptians to activate curiosity and set historical context. Optionally, highlight a female pioneer in chemistry or botany (e.g., Ellen Swallow Richards) to foster gender equity and representation.

- **Form Groups and Assign Rotating Roles**

Organize students into small, diverse teams of 3–4 learners. Assign rotating roles to encourage inclusive participation and shared responsibility. Suggested roles:

- Mixer (prepares dye mixtures)
- Observer (monitors and documents changes)
- Recorder (keeps written/color logs)
- Presenter (explains findings to class)

- **Print and Prepare Materials**

Ensure all printed resources are ready to use:

- Pigment Chemistry Quick Guide
- Kitchen Lab Safety Sheet
- Visuals of ancient pigment

Set up workstations with necessary tools: Red cabbage, lemon, baking soda

- **Review Key Scientific Concepts**

Briefly review concepts related to acids, bases, and the pH scale using a visual or video demonstration (e.g., [red cabbage pH test](#)). Ask guiding questions:

- What do you think makes a substance acidic or basic?
- Why might pigments change color in response to pH?
- How can we record these observations clearly?

- **Activate Prior Knowledge**

Invite students to share foods or household products they know that might stain or change color.

Connect these to solubility and pigment behavior. Ask:

- Have you ever noticed how lemon juice affects color?
- What natural items have you used for coloring (e.g., turmeric, berries)?



RESEARCH



Have a look at these resources

Why This Matters – Context and Relevance

Color is all around us—but it's not just visual; it's chemical, cultural, and emotional. In this activity, students explore the invisible chemistry behind color by experimenting with natural pigments found in everyday foods.

Throughout history, civilizations like the Maya and Egyptians used natural substances from plants and insects to dye clothing, paint murals, and decorate their environments. Today, many industries, from fashion to food, still rely on color chemistry to influence our decisions, evoke emotions, and represent identity.

Understanding how pH and solubility affect color not only brings science to life but also helps students become more informed about what they consume, wear, and create. By turning natural dyes into edible art, students become artists, chemists, and storytellers all at once.

Real-World Examples: Natural Color in Action

- *Red Cabbage pH Indicator:* Used in classrooms and home experiments to visualize acidity vs. basicity with color changes.
- *Turmeric in Food and Healing:* This spice has been used in Ayurvedic medicine and as a natural dye in traditional Indian clothing.
- *Beetroot in Cosmetics:* Its deep red pigment is often used in eco-friendly lipstick and blush products.
- *Food Marketing and Psychology:* Companies use color to influence appetite—red and yellow often stimulate hunger.
- *Indigo Dye in Denim:* This natural plant-based dye revolutionized textile production and cultural fashion.
- *Maya and Egyptian Pigments:* Ancient cultures developed long-lasting dyes from crushed plants and minerals to decorate temples, fabrics, and skin.

Prompt Questions to Spark Inquiry and Engagement

- Why do some foods change color when mixed with lemon or vinegar?
- What makes turmeric or beetroot good for dyeing food or fabrics?
- How have people across time used natural pigments to represent identity, culture, or status?
- Can the dyes we eat or wear affect our health or the environment?
- How could you use food science to express ideas artistically?
- In what ways do modern industries still rely on the chemistry of color?



CREATE



Some things you need before beginning

These ideas will help you understand why color, chemistry, and creativity are deeply connected—and how what you discover in this activity relates to the world around you.

- **Colors are chemistry in action.**
Natural pigments like anthocyanins (in cabbage), curcumin (in turmeric), and betalains (in beetroot) react to changes in pH. That means when you add lemon juice (acid) or baking soda (base), their molecular structure shifts and so does the color. You're not just making art, you're witnessing chemistry unfold in real time.
- **The pH scale shapes more than you think.**
From the foods we eat to the health of our oceans, pH levels affect taste, safety, soil fertility, and even the survival of coral reefs. Learning how acids and bases behave helps you understand how your body, your environment, and your food work.
- **Pigments tell cultural stories.**
Natural dyes have been used for thousands of years to communicate power, emotion, and identity. The Maya used cochineal insects to make deep reds; Egyptians used malachite for green eye paint. Every color has meaning just like your art will today.
- **Food is a canvas.**
Edible art isn't just fun, it's a powerful way to combine science, design, and sensory experience. Chefs, scientists, and artists collaborate to create color-changing cocktails, glow-in-the-dark desserts, and biodegradable packaging using plant-based pigments.
- **You are a color scientist.**
By experimenting with food-safe pigments, you're stepping into the roles of chemist, artist, and environmental designer. You'll make choices about which materials to use, how to make them react, and how to represent your message visually and all of that is part of real-world STEAM work.



Now, follow these steps

Step 1. Color Lab: experiment, compare and record

- **Ask students to prepare and think about pigments:**
 - Each team selects 2–3 natural ingredients (e.g., red cabbage, turmeric, beetroot, hibiscus).
 - Students grate, crush, or blend the materials and mix them with warm water to extract the pigments.
 - Before testing their pigments, each team will predict how their selected materials will react to acidic and basic solutions and they will write it in a paper (in order to compare their hypothesis with final results after the experiment). They will have to reflect on:
 - What do you already know about this ingredient? (e.g., Is it acidic, colorful, or used for staining?)
 - Have you seen it change color before in cooking or in nature?

- Do you think it will react strongly to acid? To base? To both?
- What kind of color change do you expect? (e.g., yellow to red? purple to green?)
- Which pigment do you think will have the biggest or most noticeable reaction? Why?
- **Ask students to experiment and test with acids and bases:**
 - Students divide each pigment into two test samples:
 - One receives a few drops of acid (e.g., lemon juice or vinegar).
 - The other receives a base (e.g., baking soda solution or soap).
 - They stir and observe the color changes, noting intensity, speed of reaction, and range.
 - Each group completes a Pigment Analysis Chart with the data gathered.

Step 2. Connect Chemistry to real life, culture and sustainability

- Ask each team to choose one culture or historical civilization from a provided list (or selects their own with approval). Suggested cultures:
 - Ancient Egypt (e.g., green malachite eye paint, red ochre lipstick)
 - Maya or Aztec (e.g., cochineal for red, annatto for orange)
 - India (e.g., turmeric and sandalwood for facial powders)
 - Japan (e.g., safflower petals in geisha lipstick)
 - Indigenous cultures (e.g., clay pigments, body paint from plants)
- Ask each team to briefly research about:
 - What natural pigments were commonly used?
 - How were they prepared and applied (e.g., for cosmetics, ritual, textiles)?
 - What did colors represent in that culture?
 - Were certain pigments linked to gender, status, or identity?
- Provide each team with a “Cultural Pigment Card” that they will have to fill out.
- After all groups have filled out the Cultural Pigment Card start a discussion (encourage them to think about: Health/safety, cost and access, environmental impact, cultural appreciation vs. appropriation):

“Based on what you learned from your culture and your experiment, which of these natural pigments could be used today as an eco-friendly replacement for synthetic dyes in food, makeup, or fabric? Why? What are the advantages and what challenges might exist?”

Step 3. Art Studio: Create with Meaning and Cultural Memory

- Each team selects a theme that unites:
 - A social or environmental issue (e.g., water pollution, cultural resilience, gender roles, natural resource use)
 - A symbol, color, or design rooted in the culture they researched (from Step 2)
 - A woman in STEAM whose legacy inspires the message or form of the artwork

Examples of theme combinations:

- “Voices in Red” – Maya cochineal + women’s representation + Ellen Swallow Richards
- “Turmeric Justice” – Indian pigment + climate justice + Sunita Narain
- “Blue Memory” – Egyptian indigo + cultural preservation + Zaha Hadid
- Ask students to use extracted pigments from Step 1 on surfaces like recycled cardboards (materials should be absorbent and allow for mixing, layering, and application of liquids)
- They will have to create an artwork which includes:
 - At least one pH-reactive pigment
 - A symbolic or traditional visual element from the researched culture
 - A color change or blend that communicates your chosen issue
 - A tribute to a woman in STEAM integrated into the name, visual concept, or message

Encourage techniques such as:

- Layering to show depth of meaning
- Splatter or tie-dye to express conflict or transformation
- Stencil use for cultural motifs or silhouettes of figures

Step 4. Write and Present a Story Card

- Each group writes a 3–5 sentence story card to accompany their artwork, including:
 - The social/environmental issue being addressed
 - How their pigment experiments and culture research informed the design
 - The woman in STEAM they are honoring and her connection to the piece
 - The scientific idea (e.g., pH, solubility, pigment interaction) visualized in the artwork



COMMUNICATE

After completing the artwork, it’s time to share the creation with peers and reflect on how science, culture, and social meaning come together through pigments and design.

- Each group will present their visual piece and read aloud their Story Card. The artwork should clearly express:
 - A social or environmental issue
 - A cultural or historical pigment tradition
 - The scientific principles behind the pigment behavior
 - A tribute to a woman in STEAM
- During the exhibition, students walk around and explore their classmates’ work. Use what they’ve learned to vote for their favorites. Choose:
 - Best scientific explanation
 - Most creative message
 - Strongest link to a real-world issue
- After the gallery walk, the class will gather in a circle for a reflective discussion. Be ready to respond to:

- What would you change next time to improve your pigment's performance or the message in your artwork?
- Which part of this experience—science, cultural research, or artistic expression—was the most powerful for you? Why?
- How could you use what you created today to raise awareness or inspire action in your community?



It is time to share!

Share your amazing work and inspire others!

#CulinaryColorsSTEAM#ScienceYouCanEAT

- LinkedIn: <https://www.linkedin.com/company/steambrace-project/posts/?feedView=all>
- Instagram: https://www.instagram.com/steambrace_eu/
- X: https://www.instagram.com/steambrace_eu/



KEEP ON LEARNING



How can I make a similar project by myself?

- Could you design your own textile artwork using natural dyes—like on a cotton tote bag, scarf, or shirt? How would you plan for pH reactions or fading over time?
- Can you create a storybook, zine, or comic using only homemade pigments as your color palette? What message or theme would your art tell using only natural materials?
- What would it look like to build a cookbook or chemistry journal where each page uses food-based inks to explain color reactions, recipes, or cultural dye traditions?
- Could you research pigments used in your family's or community's culture? How might you use them in a respectful and modern way to honor identity and sustainability?
- How could you remix this project into edible chemistry—like experimenting with natural colors in candy-making or molecular gastronomy?
- Could you host a mini pigment workshop for friends or family? What would you include to explain both the science and the story behind each color?
- Can you think of a social or environmental issue you care about? How could you use color-reactive art to raise awareness or tell a personal story about it?



Which are other connected projects?

1. Color Chemistry Documentary – The Science Behind the Hue

- Record a short documentary where you demonstrate one of your pigment experiments and

explain:

- The pH reaction or solubility principle behind it
- What cultural pigment is inspired by
- How color connects to social meaning in your work
- Interview peers or family members about natural color traditions or environmental impact.

2. Pigment-to-Fashion Project – From Nature to Textile

- Explore how to transfer natural dyes to fabric like cotton, canvas, or linen.
- Design a small fashion or accessory line (e.g., patches, scarves, printed bags) that promotes sustainability and culture.
- Add pH-reactive zones that change color when touched or sprayed—use it to tell a story!

3. Cultural Color Cards – Traditions in a Box

- Create a deck of illustrated cards, each showing:
 - A traditional pigment
 - Its origin and meaning in a specific culture
 - A modern application for sustainable living
- Use the cards as an educational tool for a school fair or workshop.



LINKS FOR FURTHER INFORMATION

- Chemistry of Natural Dyes- Article (Padma S Vankar)
https://scholar.google.com/scholar?hl=es&as_sdt=0%2C5&q=Chemistry+of+Natural+Dyes+&btnG=
- Natural Dyes and Chemistry
<https://thefoxandtheknight.com/lets-talk-natural-dyes-and-chemistry/>
- Bytesize Science
<https://youtu.be/Gwk1B66dvAM>
- What is pH?
https://youtu.be/bsqHQ_16vPI

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