SCIENCE AND
ENGINEERING FAIR

Color Change Change in Ph-Indicator Paint

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RESEARCH QUESTION

WHICH TYPE OF PAINT BINDER MOST AFFECTS THE INTENSITY OF COLOR CHANGE IN A MULTI-LAYER PH-INDICATOR PAINT IN ACIDIC AND BASIC ENVIRONMENTS?

VARIABLES

INDEPENDENT VARIABLE

- THE TYPE OF PAINT BINDER USED
- ACID OR BASE APPLIED TO PAINT
- RED CABBAGE OR TURMERIC USED AS PH INDICATOR

DEPENDENT VARIABLE –

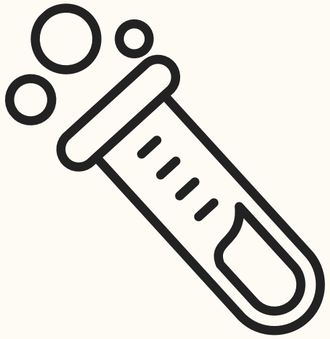
- INTENSITY OF COLOR CHANGE

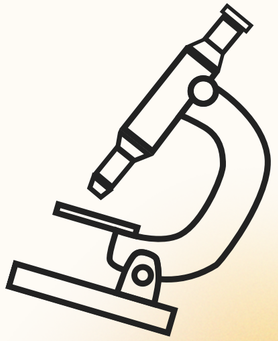
CONSTANTS

- SAME PIGMENTS (RED CABBAGE EXTRACT AND TURMERIC SOLUTION).
- SAME PIGMENT CONCENTRATION AND LAYER THICKNESS.
- SAME CANVAS TYPE AND SIZE.
- SAME DRYING TIME BETWEEN LAYERS.
- SAME ACID (VINEGAR) AND BASE (BAKING SODA) CONCENTRATIONS.
- SAME AMOUNT OF ACID/BASE APPLIED.
- SAME ROOM TEMPERATURE AND LIGHTING.
- SAME AMOUNT OF BINDER IN SOLUTIONS
- SAME AMOUNT OF PH-INDICATOR IN SOLUTIONS.

Hypothesis

IF THE PAINT BINDER IS MORE POROUS, LIKE EGG YOLK AND GUM ARABIC, THEN THE COLOR CHANGE WILL BE MORE INTENSE, BECAUSE ACIDS AND BASES CAN DIFFUSE MORE EASILY THROUGH THE PAINT LAYERS TO REACH THE PIGMENTS.





MATERIALS

MATERIALS FOR PREPARATION

- 2X HEADS OF RED CABBAGE
- 1L WATER
- 1X 1L SAUCEPAN
- 1X STOVE TOP
- 1X KNIFE
- 30G TURMERIC POWDER
- 30ML WATER
- 2X PLASTIC CUPS
- PROTECTIVE GLOVES AND APRON
- KITCHEN SCALE
- 1X TEASPOON

MATERIALS FOR TESTING

- 70 ML WATER
- 20ML WHITE GLUE
- 10G EGG YOLK POWDER
- 10G FLOUR
- 10G GUM ARABIC POWDER
- 10G CASEIN POWDER
- 9 MINI WHITE CANVAS
- 2X 5 ML PIPETTES
- 1X PAINT BRUSH
- 12X MINI PLASTIC CUPS
- 30 ML DISTILLED WHITE VINEGAR
- 15G BAKING SODA
- STOPWATCH OR TIMER
- CAMERA

PROCEDURE

PREPARE PH-INDICATOR

1. TAKE OUT ALL OF THE MATERIALS LISTED ABOVE.
2. PUT ON PROTECTIVE GLOVES AND AN APRON.
3. CHOP BOTH OF THE HEADS OF RED CABBAGES IN MEDIUM SIZED PIECES
4. PUT PIECES IN A SAUCEPAN THAT CAN HOLD IT WITH A LITER OF WATER.
5. BOIL THE SOLUTION ON THE STOVETOP AT MEDIUM-HIGH HEAT FOR 30 MINUTES THEN STRAIN AND LET IT COOL FOR 20-40 MINUTES.
6. MIX 20G OF TURMERIC POWDER WITH 4 TSP OF ROOM TEMPERATURE WATER AND STIR.
7. PUT THE TURMERIC AND RED CABBAGE SOLUTIONS IN 2 LABELED PLASTIC CUPS.

PREPARE BINDER SOLUTIONS

8. USING A KITCHEN SCALE, WEIGH 10G OF CASEIN POWDER, GUM ARABIC POWDER, DRIED EGG YOLK, AND FLOUR AND PUT EACH IN A DIFFERENT LABELED PLASTIC CUP.
9. MIX THE 10G OF CASEIN POWDER WITH 10 ML(USING 2 TSP) OF WATER AND STIR.
10. MIX THE 10G OF GUM ARABIC POWDER WITH 10 ML OF WATER AND STIR.
11. MIX THE 10G OF FLOUR WITH 10 ML OF WATER AND STIR.
12. MIX THE 10G OF DRIED EGG YOLK WITH 10 ML OF WATER AND STIR.
13. MEASURE 20 ML OF WHITE GLUE AND PUT IT INTO 1 PLASTIC CUP.

MIX PH INDICATOR & BINDERSOLUTIONS

14. WEIGH AND MIX 5G OF THE GUM ARABIC MIXTURE WITH 1TSP(5ML) OF THE RED CABBAGE SOLUTION IN A DIFFERENT MINI PLASTIC CUP.
15. REPEAT THIS WITH EVERY BINDER ADDING 5G(PASTE) OR 1 TSP(LIQUID) OF THE BINDER TO 1TSP OF THE RED CABBAGE SOLUTION.
16. WEIGH AND MIX 5G OF THE CASEIN SOLUTION WITH 1TSP(5ML) OF THE TURMERIC SOLUTION IN A DIFFERENT MINI PLASTIC CUP.
17. REPEAT THIS WITH EVERY BINDER ADDING 5G(PASTE) OR 1 TSP(LIQUID) OF THE BINDER TO 1TSP OF THE TURMERIC SOLUTION.

PREPARE ACID AND BASE

18. USING THE KITCHEN SCALE, WEIGH OUT 15G BAKING SODA INTO A PLASTIC CUP
19. USING THE TEASPOON, MEASURE 30ML OF WATER AND MIX WITH BAKING SODA.
20. MEASURE AND PUT 45ML OF DISTILLED WHITE VINEGAR INTO A PLASTIC CUP.

PROCEDURE

PAINT THE RED CABBAGE LAYERS

21. ON 1 OUT OF 6 OF THE LABELED SECTIONS OF A CANVAS, PAINT 1 LAYER OF THE RED CABBAGE & BINDER SOLUTION FOR THE BINDER THAT IS BEING TESTED.
22. SET A TIMER AND LET IT DRY FOR 60 MINUTES.
23. REPEAT THIS 6 TIMES ON THE SAME CANVAS.
24. TAKE A PICTURE OF THE CANVAS WITH THE CAMERA BEFORE THE ACID OR BASE IS APPLIED.
25. DROP 5 DROPS OF THE BAKING SODA SOLUTION ON EACH OF 3 OF THE 6 SECTIONS USING THE 5ML PIPETTE.
26. DROP 5 DROPS OF VINEGAR ON EACH OF THE OTHER 3 SECTIONS USING THE PIPETTE.
27. THEN LET IT DRY FOR TEN MINUTES USING THE TIMER.
28. USING THE CAMERA, TAKE A PICTURE OF THE RESULTS ON THE CANVAS.
29. REPEAT THESE STEPS FOR EACH BINDER OVERALL USING 5 CANVASES.
30. THEN REPEAT THESE STEPS 5 TIMES AGAIN BUT INSTEAD APPLY 5 DROPS OF WATER TO THE LAYER ONLY USING 3 LABELED SECTIONS OF THE CANVASSES FOR EACH BINDER AND RED CABBAGE MIXTURE, OVERALL HAVING 2 AND A HALF CANVASES.

PAINT THE TUMERIC LAYERS

31. ON 1 OUT OF 6 OF THE LABELED SECTIONS OF A CANVAS, PAINT 1 LAYER OF THE TURMERIC AND BINDER SOLUTION FOR THE BINDER THAT IS BEING TESTED.
32. REPEAT THIS 3 TIMES ON HALF OF THE 6 SECTIONS.
33. ON THE OTHER HALF OF THE CANVAS, PAINT 1 LAYER OF A DIFFERENT TURMERIC AND BINDER SOLUTION IN ONE SECTION.
34. REPEAT THIS 3 TIMES ON THE OTHER HALF OF THE 6 SECTIONS.
35. LET IT DRY FOR 60 MINUTES USING THE TIMER.
36. TAKE A PICTURE OF THE CANVAS WITH THE CAMERA BEFORE THE BASE IS APPLIED.
37. APPLY 5 DROPS OF THE BAKING SODA SOLUTION TO EACH OF THE 6 SECTIONS.
38. SET A TIMER FOR 10 MINUTES AND LET THE PAINT DRY.
39. TAKE A PICTURE OF THE CANVAS SHOWING THE RESULTS.
40. REPEAT THESE STEPS FOR EACH BINDER OVERALL USING 2 AND A HALF CANVASES, ONLY DOING ONE BINDER ON THE HALF OF THE CANVAS.
41. THEN REPEAT THESE STEPS 5 TIMES AGAIN BUT INSTEAD APPLY 5 DROPS OF WATER TO THE LAYER USING 3 LABELED SECTIONS OF THE CANVASSES FOR EACH BINDER AND TURMERIC MIXTURE.

PROCEDURE CON'T

RECORD DATA

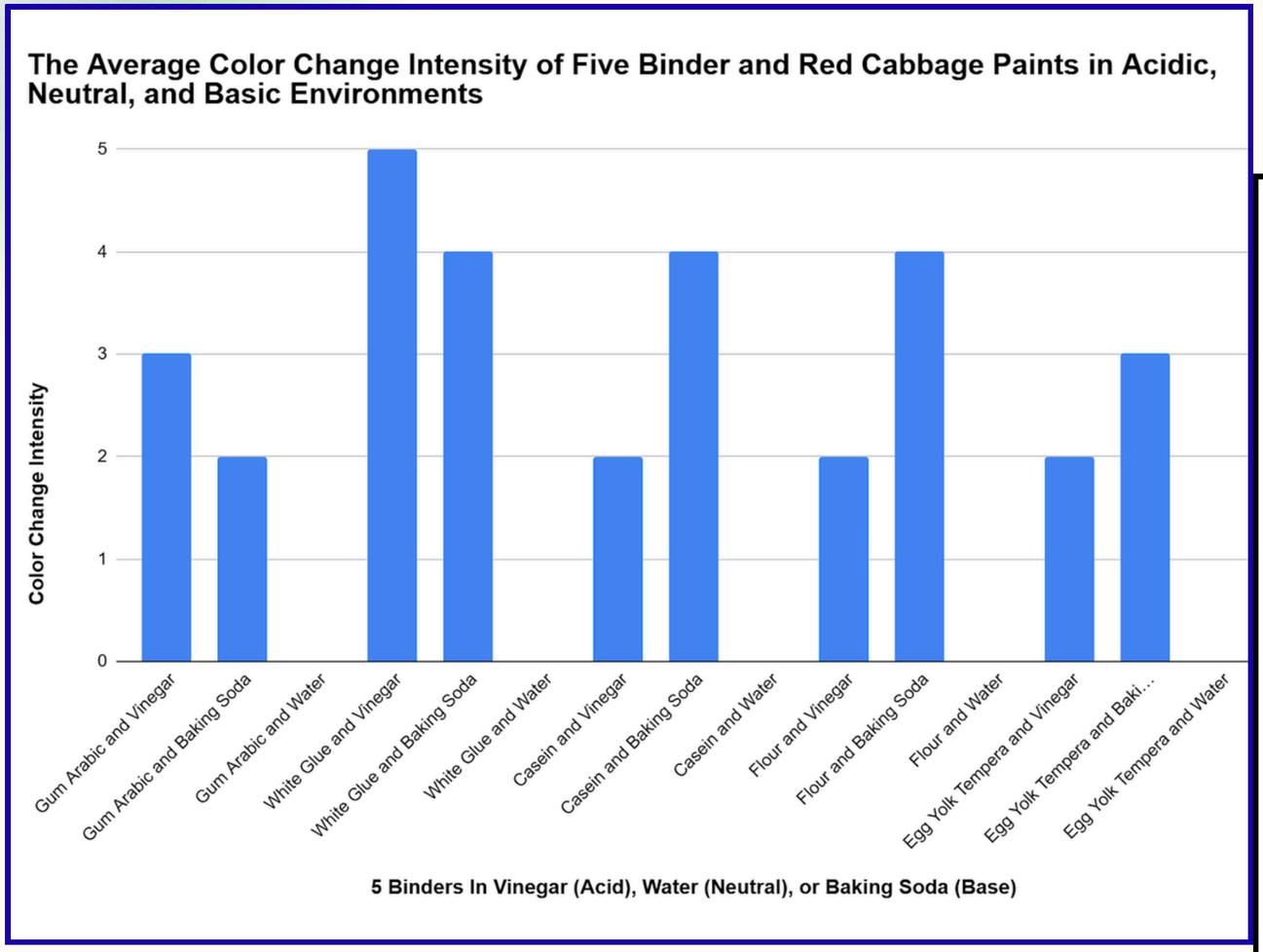
42. AFTER DRYING FOR 10 MINUTES, FOR EACH PH INDICATOR PAINT RATE THE COLOR CHANGE INTENSITY ON A SCALE OF 1–5 (1 = VERY LITTLE CHANGE, 2= FAINT CHANGE, 3= MEDIUM CHANGE, 4= STRONG CHANGE, 5 = VERY STRONG CHANGE).
43. WRITE DOWN ANYTHING THAT IS OBSERVED ABOUT THE PAINTS.
44. FOR EACH PH INDICATOR PAINT MADE, AVERAGE THE RESULTS OF THE 3 TESTS FOR THE AVG. COLOR CHANGE INTENSITY.

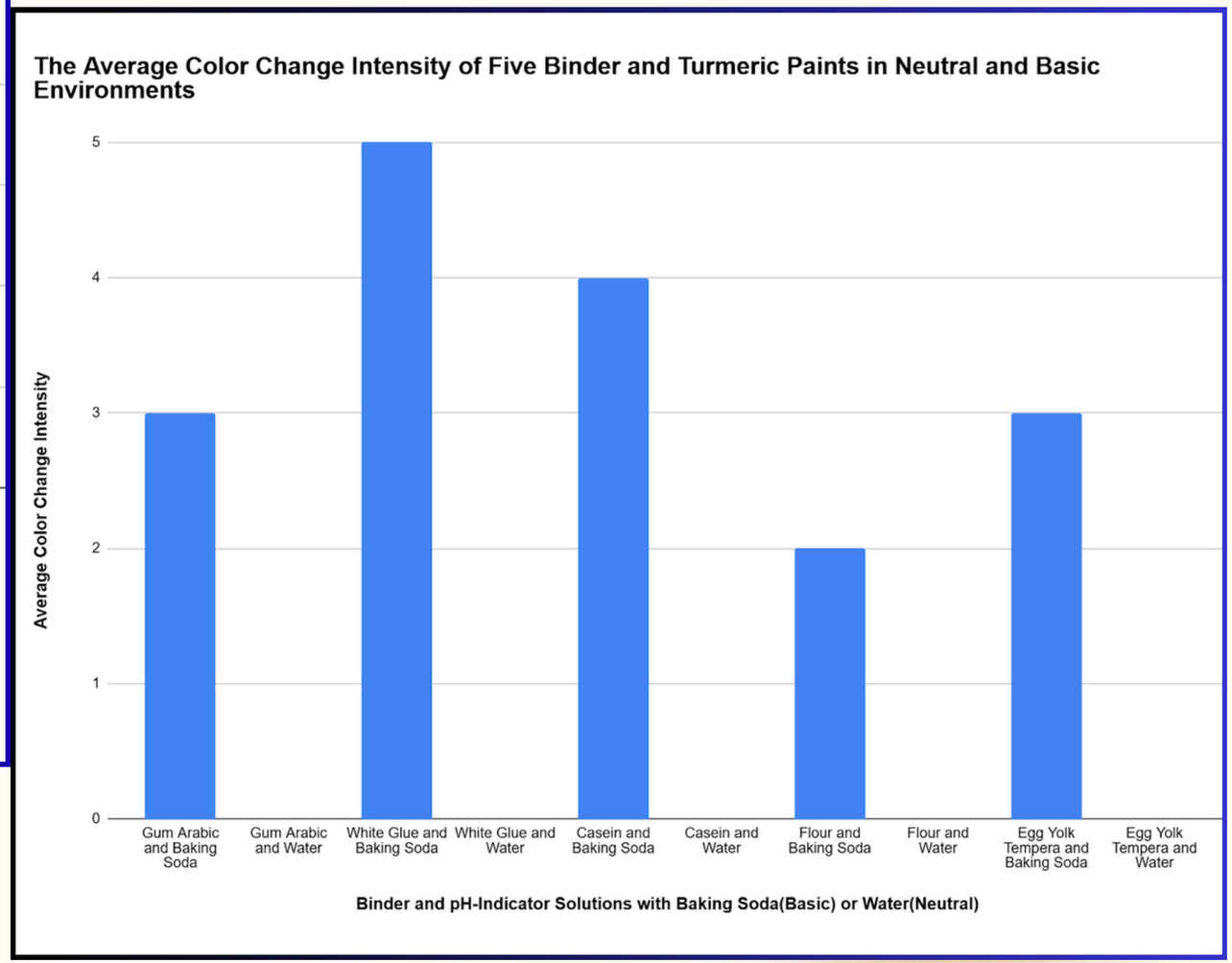
Binder and Turmeric Results

Binder type	Average Color Change Intensity	Water, Vinegar, or Baking Soda used	Start color	Result Color	Observations
Gum Arabic	3	Baking Soda	Tanned Yellow	Crimson Red	Little red and yellow spreading, little bubbles
Gum Arabic	0	Water	Tanned Yellow	Tanned Yellow	Thin, glossy
White Glue	5	Baking Soda	Dark Muddy Yellow	Very Dark Brown	Little red spreading, sandy texture
White Glue	0	Water	Dark Muddy Yellow	Dark Muddy Yellow	Thick, sandy texture
Casein	4	Baking Soda	Bronzed Yellow	Dark Brown	Sandy texture, little-no red and yellow spreading
Casein	0	Water	Bronzed Yellow	Bronzed Yellow	Sandy Texture, little-no red and yellow spreading
Flour	2	Baking Soda	Dark Yellow/Orange	Chocolate Brown	Little red spreading, tiny cracks
Flour	0	Water	Dark Yellow/Orange	Dark Yellow/ Orange	Medium thickness, smooth
Egg Yolk Tempera	3	Baking Soda	Dark Yellow	Very Dark Red/ Orange	Chunky, Medium brown and yellow spreading
Egg Yolk Tempera	0	Water	Dark Yellow	Dark Yellow	Sandy texture, medium thickness

Binder and Red Cabbage Results

Binder type	Average Color Change Intensity	Water, Vinegar, or Baking Soda used	Start color	Result Color	Observations
Gum Arabic	3	Vinegar	Deep Sea Green	Pale Lavender	Large teal blotches
Gum Arabic	2	Baking Soda	Deep Sea Green	Dark Emerald Green	Little-no spreading, constant color
Gum Arabic	0	Water	Deep Sea Green	Deep Sea Green	Very Glossy, consistent color
White Glue	5	Vinegar	Light Lavender/Blue	Deep Teal Blue/ Green	Constant color, Medium Spreading
White Glue	4	Baking Soda	Light Lavender/Blue	Pale Mint/ Lime Green	Blue residue, Substantial Spreading
White Glue	0	Water	Light Lavender/Blue	Light Lavender/Blue	Watery
Casein	2	Vinegar	Pale Violet Purple	Light Magenta	Outer blue spread, Large cracking, Under bubbling
Casein	4	Baking Soda	Pale Violet Purple	Clover Green	Faint purple spread, Under bubbling, Large cracking
Casein	0	Water	Pale Violet Purple	Pale Violet Purple	Little white chunks
Flour	2	Vinegar	Pale Purple/Gray	Pastel Lilac	Large dark purple chunks, medium light blue spreading
Flour	4	Baking Soda	Pale Purple/Gray	Mint Green	Large dark green chunks, Faint little spreading, Medium sized cracks
Flour	0	Water	Pale Purple/Gray	Pale, Purple/Gray	Dark purple chunks, reasonably thick
Egg Yolk Tempera	2	Vinegar	Dark Olive Green	Light Emerald Green	Slight yellow residue, Under Bubbling, No spread
Egg Yolk Tempera	3	Baking Soda	Dark Olive Green	Dark Bronze Yellow	Slight green tinge, Tiny bubbles, Little cracks, Faint spread
Egg Yolk Tempera	0	Water	Dark Olive Green	Dark Olive Green	Splotchy





RESULTS- GRAPHS

CONCLUSION

THE HYPOTHESIS STATED THAT IF THE PAINT BINDER IS MORE POROUS, LIKE EGG YOLK AND GUM ARABIC, THEN THE COLOR CHANGE WILL BE MORE INTENSE, BECAUSE ACIDS AND BASES CAN DIFFUSE MORE EASILY THROUGH THE PAINT LAYERS TO REACH THE PIGMENTS. THIS WAS PARTIALLY CORRECT, FOR BOTH GUM ARABIC AND EGG YOLK HAD AN AVERAGE COLOR CHANGE INTENSITY OF 2.5 IN THE RED CABBAGE SOLUTION AND 3 WITH THE TURMERIC SOLUTION. HOWEVER, THE BINDER WITH THE MOST INTENSE CHANGE WAS WHITE GLUE WITH AN AVERAGE OF 4.5 WITH RED CABBAGE AND AN AVERAGE OF 5 WITH TURMERIC, EVEN THOUGH IT IS LESS POROUS THAN BOTH EGG YOLK AND GUM ARABIC.THIS COULD BE BECAUSE WHITE GLUE RETAINS MOISTURE AND TRAPPED THE PH INDICATOR PIGMENTS CLOSE TO THE SURFACE. OVERALL, WHILE MORE PERMEABLE BINDERS SUCH AS EGG YOLK AND GUM ARABIC OFTEN ALLOWED GREATER COLOR SPREADING, THE STRONGEST COLOR CHANGE INTENSITY WAS NOT PRODUCED BY THE MOST POROUS BINDERS. A POSSIBLE ERROR IN THIS EXPERIMENT'S PROCEDURES COULD BE AN UNEVEN PAINT LAYER THICKNESS OR AN UNCONSTANT DROP PLACEMENT ON A LAYER. FURTHER STUDIES AND PROJECTS COULD TEST THE POROSITY OF SOLUTIONS MORE DIRECTLY TO DETERMINE WHETHER DIFFUSION RATE DIRECTLY CORRELATES WITH COLOR INTENSITY.