Colour in Food

At a glance

	Content summary	National Curriculum links	Activities
Lesson 1	Understanding why food is coloured. Extracting food colours from plant material. Discussion of perceptions and associations we have for food colour	Understanding mixtures Using filtration to separate a mixture	**Activity A:** Why is food coloured? **Activity B:** What substances make food appear coloured? Preparing natural food colours
Lesson 2	Separating the chemicals in natural and artificial food colours using chromatography	Working scientifically	**Activity C:** What substances make food appear coloured? Testing food colours using paper chromatography

Background and National Curriculum links

These activities are intended for two lessons for Year 7-9 students focusing on colour in food. The first lesson includes discussion about food colour and preparation of natural food colours. In the second lesson, students compare natural and artificial food colourings using chromatography. In either or both lessons students can discuss perceptions and associations of colour in food with health, seasons and holidays, food quality and eating well.

Lesson 1

Lesson 1 starts with a discussion about why food is coloured. This can be developed into discussion of, for example, colour perception, why food is coloured in nature and the chemicals that comprise colour. Next students use simple procedures to extract food colours from plant material.

National curriculum:

- Students work scientifically. They use an appropriate technique and materials to undertake an experiment involving extracting colour from natural materials.
- Students use filtration to separate a mixture. The lesson reinforces understanding of mixtures.

Lesson 2

In Lesson 2, students separate chemicals in the natural food colours from Lesson 1 using paper chromatography. They can compare the separation patterns with those for artificial food colours. The lesson gives an opportunity to discuss preferences for food colour and associations of foods with religious and other festivals.

National curriculum:

- Students use chromatography to separate mixtures. They identify if any food colours are pure substances. Working scientifically, they may consider reliability of the method and suggest improvements.

Teacher subject knowledge

- The lessons can be taught by a science teacher of any subject background.
- A Religious Education specialist may help maximise potential from cross-curricular links in Lesson 2.

Cross-curricular links: food additives and food associated with religious festivals

For centuries, humans have enhanced food colour to make it more appetising and to enhance flavour. Seeing strong colours contributes to our sense of taste: grey food looks tasteless. Adding spices such as saffron and turmeric create warm yellow colours; extracts from pomegranates, beetroot and berries add red and pink colours; while spinach, parsley and other leaves add green colours. Natural food colours are expensive to extract, so when synthetic dyes became available, from the mid-nineteenth century onwards, chemists adapted these into cheap food additives. Today, tightly regulated additives are used in many food products. For example, some brands of strawberry ice cream create flavour and colour mainly from artificial additives. Manufacturers choose a strawberry flavour (wild, sour or grassy) and colour. Artificially flavoured and coloured strawberry ice cream is brighter pink and keeps longer than ice cream made with real strawberries, which is usually a pale pink colour.

Specific foods are associated with religions and religious festivals. Yellow-coloured saffron rice is often served during the Holi festival; in Christianity, oil of cassia, symbolising perfume used to anoint Christ's body, is used in Easter biscuits; in Indonesian Islam, beef rendang contains chilli, symbolising interpreters of religious knowledge, and coconut milk symbolising teachers; in Judaism, etrog is a yellow citrus fruit used in the Sukkot festival.

Student background knowledge

The lessons build on students' prior knowledge, experiences and tastes in food. They will question and investigate their perceptions and opinions about food colour. No prior scientific knowledge is required.

Resources and timing

One or two 50 – 60 minute lessons are required.

Technical requirements

Lesson 1

Activity A: Why is food coloured?

Have available images of a 'food rainbow' (Figure 1) and yellow, green and black bananas (Figure 2).

Other food images can be added as desired.

Activity B: What substances make food appear coloured?
Preparing natural food colours

Divide students into four groups, each making one food colouring. Depending on the size of the class, two or three sets of equipment (Table 1) will be required for each food colour. The instructions (see Activities) make about 200 cm^3 of liquid pink/red, green, yellow and purple food colourings. The methods can be adapted for use with other natural substances (see Resources).

If the intention is to use the food colourings in food preparation (see Extension), prepare them as described on the Activities sheet using only kitchen equipment (Table 1) in a food technology room. The food colourings can be stored in airtight containers in a (food grade) refrigerator for up to six weeks.

If the colours will not be eaten, students can extract the colours in a science laboratory using a combination of kitchen equipment and science equipment (Table 1).

Table 1: Equipment required for extracting pink/red, yellow, purple and green colourings from food.

Colour	Food item	Kitchen equipment only	Kitchen and science equipment
Pink / red	About 60 g cooked / canned / pre-packaged beetroot (Bake or boil fresh beetroot first) or 100cm^3 beetroot juice from a can / cooking liquid	Blender / masher 100 cm^3 water Measuring jug Sieve Large metal spoon Storage jar / container with lid	Blender / masher 100 cm^3 water 100 cm^3 measuring cylinder 500 cm^3 / 1 litre beaker Filter funnel, filter paper Large spatula Test tubes / boiling tubes with stoppers
Purple	About 100 g blueberries fresh or frozen (thawed before use). Frozen berries seem to produce a deeper colour	Blender / masher 100 cm^3 water Measuring jug Sieve Bowl Large metal spoon Storage jar / container with lid	Blender / masher 100 cm^3 water 100 cm^3 measuring cylinder 250 cm^3 beaker Filter funnel, filter paper Large spatula Test tubes / boiling tubes with stoppers
Yellow	Two teaspoons ground turmeric	Small saucepan 200 cm^3 water Wooden spoon (note, this may stain) Storage jar / container with lid (note, this may stain) Access to a gas / electric hob	500 cm^3 /1 litre beaker 200 cm^3 water Large spatula Test tubes / boiling tubes with stoppers Bunsen burner, heatproof mat, tripod, gauze
Green	About 60 g spinach, fresh or frozen (thaw and drain)	Blender / masher 200 cm^3 water Sieve Bowl Large metal spoon Measuring jug Storage jar / container with lid For fresh spinach: Small saucepan Access to a gas / electric hob Wooden spoon	Blender / masher 100 cm^3 water Filter funnel, filter paper 500 cm^3 /1 litre beaker Large spatula 100 cm^3 measuring cylinder Test tubes / boiling tubes with stoppers For fresh spinach: 500 cm^3 /1 litre beaker Bunsen burner, heatproof mat, tripod, gauze Large spatula

Activity C: What substances make food appear coloured? Testing food colours using paper chromatography

To prepare food colourings for testing, decant into sets of small beakers / sample bottles for ease of access. Pre-testing the solvent is recommended to ensure separation occurs.

Each pair or group of students will need:

- 250 ml beaker
- Chromatography paper about 10cm x 10cm
- HB pencil
- Ruler
- Pasteur pipette or cocktail stick
- Access to a solvent, for example, 98% ethanol, propanone or isopropylalcohol (propan-2-ol)
- Watch glass or cover for the beaker
- Samples of natural food colours prepared in Activity B
- Artificial food colours for comparison – these are readily available from supermarkets

Activities

Lesson 1

Activity A: Why is food coloured?

1. Discuss with students:
   a. The variety of colours we see in food. Create a 'rainbow' of examples of foods on the whiteboard. Alternatively, show an image of a food rainbow (Figure 1). Ask students to identify foods they recognise in the image.

Figure 1: Image of a food 'rainbow'.
(source: food-rainbow-810x425.jpg (810×425) (sunnybrook.ca))

   b. Why is food so varied in colour? Ask for their ideas. Some scientific answers include:
      - In Figure 1, the foods are all plants. The colour depends on the plant itself. The same type of plant can produce fruit with different colours, e.g. green and red apples and peppers. These have evolved over time; some varieties have been created by plant specialists.
      - Naturally occurring coloured pigments in plant cells are responsible for the colours. The pigments are chemical compounds.
      - The environment in which food is grown may influence its colour, as well as where the plant lies in an ecosystem. For example, brightly coloured berries are ripe and visible, birds see and eat them. Brown and yellow mushrooms are eaten by forest animals such as deer, moose, bears and wild boar.

c. Why is colour in food important?

- Colour implies healthy food that stimulates appetite and a desire to eat.
- Food colour tells us if food is ripe and good to eat or rotten. Bananas are picked green, change to yellow when ripe and go black and soft when over-ripe (Figure 2). Which bananas would students eat and why?

Figure 2: Green, yellow and black bananas
(source: image of green yellow and black bananas - Bing images)

- Fruit colours tell animals 'food is available'. Eating fruit spreads seeds as part of a plant's reproductive cycle.
- Many coloured pigments have health benefits, including lycopenes in tomatoes (red); carotenes in carrots (orange); chlorophyll in leaves (green).
- Imagine if all food had no colour – what might this be like?
- Some foods of specific colours and flavours are associated with religious festivals and seasons.

d. What colour foods do students prefer to eat? Why?

e. What colour foods would students not eat? Why? (See Figure 2)

Resources

The American Chemical Society published 'Eating with your Eyes: The Chemistry of Food Colourings' by Brian Rohrig in *Chemistry Matters*, October 2015, which is available as a pdf via this link: https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/2015-2016/october-2015/food-colorings.html

Activity B: What substances make food appear coloured?
Preparing natural food colours

If the colours will be used later to prepare food that students will eat, extract the food colourings in a food technology room, and follow instructions for kitchen equipment.

If the colours will NOT be eaten later by students, extract the food colourings in a science laboratory and follow instructions for kitchen and science equipment.

Pink/red colour from beetroot

Kitchen equipment	Kitchen and science equipment
■ In a blender or food processor, or by hand-mashing, blend the beetroots, juice and water together until smooth. ■ Set a sieve over a bowl. ■ Place the mixture in the sieve. ■ Press the mixture in the sieve using the metal spoon, pressing down on the pulp so that beetroot liquid passes through into the bowl. This liquid is the food colouring. ■ Transfer the liquid to an airtight container. ■ The colouring can be stored for up to six weeks in the refrigerator.	■ In a blender or food processor, or by hand-mashing, blend the beetroots, juice and 100 cm^3 water together until smooth. ■ Set a filter funnel with filter paper over a large beaker. ■ Place some of the mixture into the filter paper. Allow the liquid to drain through. ■ Change the filter paper and add more mixture to the funnel. Repeat until all the mixture is filtered. The liquid in the beaker is the food colouring. ■ Transfer the liquid to test /boiling tubes. Stopper the tubes. ■ The colouring liquid can be stored for up to six weeks in a refrigerator.

Yellow colour from turmeric

Kitchen equipment	Kitchen and science equipment
■ Place 200 cm^3 water in the saucepan. ■ Add 2 teaspoons of turmeric powder. ■ Stir with the wooden spoon. ■ Heat the mixture to boiling then simmer for three minutes. ■ Cool the liquid to room temperature. ■ Transfer the liquid to an airtight storage container.	■ Measure 200 cm^3 water into the beaker. ■ Add two spatulas of turmeric powder. ■ Stir with the spatula. ■ Set the mixture over a Bunsen burner. ■ Heat the mixture to boiling. Turn down the gas and simmer gently for 3 minutes. ■ Allow the mixture to cool. ■ Transfer the mixture to test / boiling tubes. ■ Stopper the tubes.

Purple colour from blueberries

Kitchen equipment	Kitchen and science equipment
■ In a blender or food processor, or by hand mashing, blend about 100 g blueberries and water together until smooth. ■ Set a sieve over a bowl. ■ Place the mixture in the sieve. ■ Press the mixture in the sieve using the metal spoon, pressing down on the pulp so that blueberry liquid passes through into the bowl. This liquid is the food colouring. ■ Transfer the liquid to an airtight container. ■ The colouring can be stored for up to six weeks in the refrigerator.	■ In a blender or food processor, or by hand mashing, blend 100 g blueberries and 100 cm^3 water together until smooth. ■ Set a filter funnel with filter paper over a large beaker. ■ Place some of the mixture into the filter paper. Allow the liquid to drain through. ■ Change the filter paper and add more mixture to the funnel. Repeat until all the mixture is filtered. The liquid in the beaker is the food colouring. ■ Transfer the mixture to test /boiling tubes. Stopper the tubes.

Green colour from spinach

Kitchen equipment	Kitchen and science equipment
For fresh spinach ■ Place 60 g spinach in a small saucepan. ■ Add the water. Use a wooden spoon to press the leaves under the water. ■ Bring the mixture to the boil then simmer for three minutes. Do not cover. ■ Cool the mixture then continue as for frozen spinach. **For frozen spinach** ■ In a blender or food processor or by hand-mashing, blend 60 g spinach and 100 cm^3 water completely smooth. ■ Set a sieve over a bowl. ■ Place the mixture in the sieve. ■ Press the mixture in the sieve using the metal spoon, pressing down on the pulp so that spinach liquid passes through into the bowl. This liquid is the food colouring. ■ Transfer the liquid to an airtight container. ■ The colouring can be stored for up to six weeks in the refrigerator.	**For fresh spinach** ■ Place 60 g spinach into a large beaker. ■ Add 100 cm^3 water. Use a spatula to press the leaves under water. ■ Set the mixture over a Bunsen burner. ■ Heat the mixture to boiling. Turn down the gas and simmer gently for 3 minutes. ■ Cool the mixture then continue as for frozen spinach. **For frozen spinach** ■ In a blender or food processor or by hand-mashing, blend 60 g spinach and 100 cm^3 water completely smooth. ■ Set a filter funnel with filter paper over a large beaker ■ Place some of the mixture into the filter paper. Allow the liquid to drain through. ■ Change the filter paper and add more mixture to the funnel. Repeat until all the mixture is filtered. The liquid in the beaker is the food colouring. ■ Transfer the liquid to test /boiling tubes. Stopper the tubes. ■ The colouring liquid can be stored for up to six weeks in a refrigerator.

Which steps require these processes?

- Macerating – mashing the beetroot, blueberries and spinach is maceration.
- Extraction – the whole process is extraction.
- Dissolving – heating the spinach and turmeric dissolves the colour in water.
- Filtration – placing the mixtures of blueberry, beetroot and spinach in a filter funnel with paper.
- Pouring – decanting the coloured liquid into test / boiling tubes involves pouring.

Discuss if the final colours can be described as a:

- Suspension – no, this is a solid particles held in a liquid medium.
- Solution – yes, the colours are dissolved in water.
- Emulsion – no, this is a mixture of two liquids that do not usually mix, such as oil and water.
- Filtrate – yes, the coloured liquids passed through filter paper so are filtrates.

Extensions

- Make more natural colours
  - A chart showing additional natural colours with their Pantone colour scale points is available at: https://sensientfoodcolors.com/en-eu/wp-content/uploads/2018/04/Colors-from-Around-the-World1.pdf
  - The activity can be extended by using additional materials from this list and adapting the processes outlined above.
- Tasting natural food colours
  - Taste the natural colours prepared in Activity B. Do they taste of the original plant materials? What do they notice?
  - Students can use their prepared natural food colours to colour icing (frosting). A tub of prepared, soft, white cake frosting and plain biscuits or cupcakes are required. Students can mix colours to make new, potentially 'yucky' colours. Preparing a comparison set with artificial colours would permit comparison of perceptions.
  - Ice the biscuits / cakes separately with naturally and, if used, artificially coloured icing. Additional elements, such as edible stars or glitter could be added.
  - Arrange a charity cake sale, benefitting a charity associated with vision. Sell the products for donations, noting which colours go first. Discuss what this shows about how manufacturers use colour to promote food products and what our brains tell us is 'healthy' or 'good' to eat.

- Make cakes / biscuits from scratch, using the natural colourings as instructed
  - The BBC Food website has a range of recipes at: https://www.bbc.co.uk/food/food_colouring. Use natural colours as the recipes suggest. Discuss if the products look edible – if not, why not? How does the colour contribute to students' ideas about which foods they would eat?

Lesson 2

Activity C: What substances make food appear coloured? Testing food colours using paper chromatography

In this lesson, paper chromatography is used to investigate the natural colours produced in Activity B. They can be compared with artificial colours. To set up paper chromatography:

1. Draw a pencil line about 2 cm from one end of a piece of chromatography (filter) paper.
2. Make intense spots of each colour about 3 cm apart along the line by carefully placing drops from the tip of a Pasteur pipette or a cocktail stick. Take care not to allow the spots to become too large. To get an intense spot, allow the colours to dry then repeat with another drop over the previous one. Label each carefully in pencil, e.g. 'R', 'Y', 'G', 'P'.
3. Stand the paper in a beaker with solvent in the base. Make sure the solvent level is below the pencil line.
4. Cover the beaker with a watch glass.
5. Leave the set up for about 2 – 3 minutes for the solvent to move upwards. Watch carefully – take the paper out when the solvent front reaches about two-thirds of the way up.
6. Lay the test paper to dry on paper towels.
7. Look carefully at the pattern of bands produced.

Make a comparison chromatogram with artificial food colours of similar shades.

Are there any differences in the chromatograms? For which colours?

- This question cannot be answered as this depends entirely on the samples used. There should be differences between the natural and artificial colours.

What causes the differences in band patterns?

- Each food colour is likely to be a mixture of different chemicals. Artificial colours will be made from different chemicals to those in natural food colours.

What foods are coloured using artificial colours?

Examples of artificial colours with their 'E' code numbers include:

- carmine (E120) – red, used in fruit juice, ice cream, yoghurt, sweets;
- tartrazine (E102) – yellow, used in soft drinks, crisps, popcorn;
- brilliant blue (E133) – greenish blue, used in ice cream, canned peas, soup;
- green S (E142) – green, used in sauces, canned peas, desserts, gravy granules.

Resources

The US-based company Sensient Food Colors has a useful website and access to free resources in exchange for an email sign-up: https://sensientfoodcolors.com/en-eu/about-us/
Also in the US, Jenn David Design discusses how food colours impact sales:
https://jenndavid.com/colors-that-influence-food-sales/