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Additional Material

Tea-time chemistry

Scientific background

The tea plant, *Camellia sinensis,* is a species of bush in the plant family Theaceae, which also includes genera such as the ornamental camellias. There are varieties of tea plants whose cured leaves and leaf buds are processed differently to produce distinct types of tea (including white, green, and black tea).

Herbal teas, or tisanes, are commonly and commercially called teas, but this is technically incorrect since they are not made from leaves of the tea plant, but from infusions of fruits, spices, herbs and other plant material in hot water. Unlike true tea, most tisanes do not contain caffeine (which is often called theine when found in tea).

The composition of teas and tisanes are complex because the plant materials from which they are made contain hundreds of chemical compounds. In addition, when tea leaves are processed, their chemical compounds break down and react, forming new compounds. The most important compounds in fresh tea leaves are polyphenols (such as tannins and anthocyanins), amino acids, methylxanthines (such as caffeine and theobromine), enzymes, carbohydrates, minerals, and volatile flavour and aroma compounds.

Extension activities

The following are some additional experiments and activities you can carry out with your students using tea, herbal tea, and even teabags to learn about other topics beyond chemistry.

- Use teabags for measuring the rate of decomposition of the organic matter in the tea (with the release of carbon dioxide) through studying how the mass of tea bags changes after being buried in the ground for a few months You can find more information about a global litter decomposition initiative at: https://www.teacomposition.org/
- Make a 'teabag rocket'. Cut open a tea bag so it forms the shape of a cylinder, and empty out the contents. Set light to the tea bag at the top. Hot air rises because it is less dense, and cold air falls because it is more dense, so at the point where the tea bag has lost enough mass, this effect overcomes the force of gravity and it rises up.
- Carry out chromatography with different types of tea and herbal teas to appreciate their different and complex compositions. You can find out how to do this from this *Science in School* article about using chromatography to separate pigments in leaves: Tarragó-Celada, Fernández Novell JM (2019) Colour, chlorophyll and chromatography. *Science in School* **47**: 41-46.

Further discussion ideas

- Discuss with your students the different names of some common chemical compounds. For example, $NaHCO_3$ has the systematic IUPAC name of sodium hydrogencarbonate, but it is also known as sodium bicarbonate. In the home it is commonly called bicarbonate of soda, baking soda, bread soda, cooking soda, or sometimes simply 'bicarb'. $NaHCO_3$ is also the food additive E500. Ask your students:
  - Do different names change the way chemicals are perceived?
  - Does baking soda sound less scary than $NaHCO_3$ or E500?
  - How about L-ascorbic acid or E300? Would you want this in your food? It's actually vitamin C.

- Discuss with your students whether sodium hydrogencarbonate (sodium bicarbonate) is an acid or base. In fact, it is amphoteric, which means it can act as either an acid or as a base. This is due to the fact that the hydrogencarbonate (bicarbonate) ion can either donate a hydrogen ion, acting as an acid, or accept a hydrogen ion, acting as a base. When dissolved in water, it is usually considered to be a slightly basic substance because the solution has a pH of around 8.3 due to its ability to take a hydrogen ion from a water molecule being greater than its ability to donate a hydrogen ion to a water molecule. The chemical reaction causing the solution to be basic is:
  $HCO_3^-(aq) + H_2O(aq) \rightleftarrows H_2CO_3(aq)) + OH^-(aq)$
  The H_2CO_3 is also part of another equilibrium process:
  $H_2CO_3(aq) \rightleftarrows CO_2(g) + H_2O(aq)$

- Students can explore the historical, economical and other factors linked to the manufacture of tea and its trade. For example, one famous event is the Boston Tea Party in 1773. This was a political protest against British taxation of products including tea, which escalated into the American Revolution.
- Ask your students to use the internet to learn about the chemistry involved in the process of bleaching of fabrics and clothes, and its importance now and in history.
- Ask your students if they have heard of the antioxidant power of fruits and vegetables?What does it mean? Antioxidants are compounds that inhibit oxidation by acting as reducing agents. They are often thought to be beneficial to health since environmental oxidants can cause cell damage, although the situation is in fact much more complex. The antioxidant activity of various types of food and drinks can be tested easily. See: Farusi G (2009) Looking for antioxidant food.*Science in School* **13**: 39-43. Although there are a set of complex chemical reactions, the reducing and oxidant power of teas is mainly due to the presence of anthocyanins.