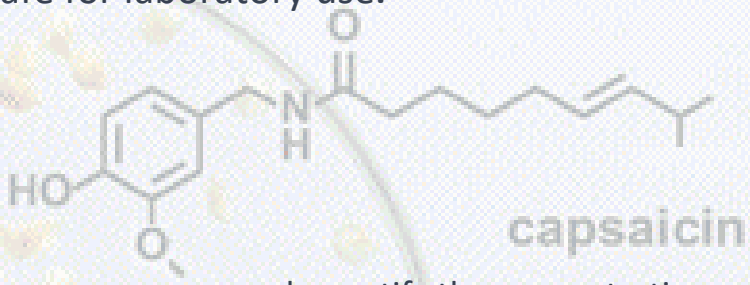
SOLVENT EXTRACTION OF CAPSAICIN

Capsaicin is the active component responsible for the pungency and spiciness in red chilli peppers. It is also the active ingredient in pepper spray used by riot squads during civil disobedience. Extracting capsaicin from these peppers allows for its isolation and further study. In this practical experiment, we will employ ethanol as a solvent to extract capsaicin from green and red chilli peppers. Ethanol is chosen for its ability to dissolve capsaicin efficiently while being relatively safe for laboratory use.



capsaicin

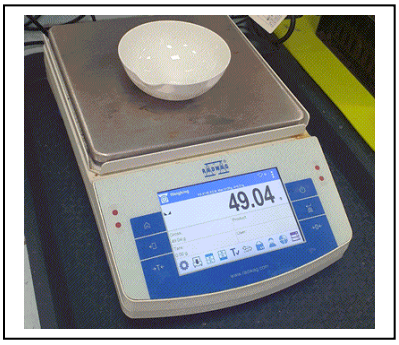
Aim To extract capsaicin from red and green peppers and quantify the concentration, in %m/m, of capsaicin in each variety of pepper.

Apparatus:

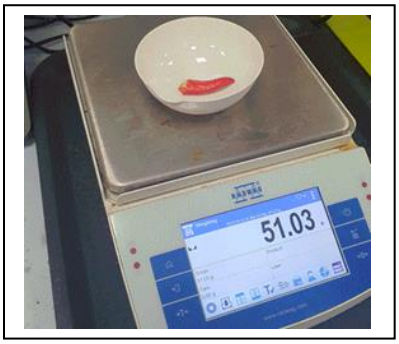
- A collection of green and red chilli peppers
- 1 X Mortar and pestle
- Ethanol 30 mL
- 1 X Filter paper
- 1 X 100 mL beaker
- 1 X plastic funnel
- 1 X small spatula
- 1 X glass rod
- 1 X evaporating dish
- 1 X Electronic weighing scale (3 decimal places)
- Safety goggles and gloves
- Access to fume cupboard.
- 2.00 grams of washed river sand
- Retort stand and ring clamp.

Procedure

1. Weigh an evaporating dish using the electronic balance and record the reading.



2. Select a pepper, remove the seeds and stem, place into the preweighed evapoating dish and weigh. Record the reading.



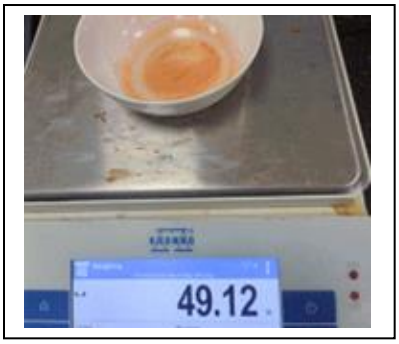
3. Grind the flesh of the pepper using a mortar and pestle and a small spatula of river sand. Grind to a fine paste to increase the surface area

4. Using half of the ethanol, rinse the pestle into the mortar and stir the solution with a glass rod.

5. Set up the retort stand with the ring clamp and secure the funnel and filter paper as shown on the right. Pour the contents of the mortar into the filter paper and rinse with the remainder of the ethanol. Collect the filtrate in the pre-weighed evaporating dish, as in step 1. Rinse the particles in the filter with the remaining ethanol.

6. Remove the evaporating dish and leave in a fume-cupboard overnight for the alcohol to evaporate. Weigh the evaporating dish with its contents and record the result.

7. Repeat steps 1-6 with another variety of pepper.



Results

Pepper	Mass of evaporating dish (g)	Mass of evaporating dish and sample (g)	Mass of sample (g)	Mass of evaporating dish and dried filtrate (g)	Mass of capsaicin (g)	Concentration of capsaicin %m/m
Green						
Red						

Questions

1. Suggest 2 improvements to the procedure and explain how each suggestion will impact ***one*** of the three factors accuracy, validity or repeatability. You may use each factor only once.
   4 marks

Any of the below but not limited to:

- *Increase the number of trials conducted for each pepper. ---- 1 mark*
  - *This minimises the impact of random errors and increases the validity of the results. ----- 1 mark*

- *Use a hot plate to evaporate the ethanol and measure the evaporating dish with filtrate to constant mass. --- 1mark*
  - *Increases validity, ensures that the filtrate is completely dried of solvent and the mass measured is due to, we assume, capsaicin ---- 1 mark*
- *Use the same size pepper for each variety and the same age of pepper. ----- 1 mark*
  - *This increases validity as it eliminates other independent variables such as size and age of the sample ------ 1 mark*
- *Increasing the sample size of the peppers. Using several peppers to grind at once in the mortar and pestle. --- 1mark*
  - *Larger mass samples contribute to improved repeatability. With larger samples, the experiment becomes more robust, reducing the influence of random variability between samples and within samples. It may be that capsaicin is only produced at certain location in the flesh of the pepper. The results are likely to be more consistent across repeated trials, enhancing the overall repeatability of the experiment. ----- 1 mark*
  - *Validity is also improved as we are measuring the amount of capsaicin in a greater representative mass of pepper. ----- 1 mark*

- *Use a more non-polar solvent, such as hexane, to selectively target the non-polar capsaicin molecule. ---- 1 mark*
  - *Validity is improved using hexane as it eliminates all the polar compounds also extracted with ethanol but are not extracted by hexane---- 1 mark*

Any other valid improvement with a relevant and logical explanation of how it will improve the investigation.

2. What is the :

Dependent variable _____*concentration of capsaicin (%m/m)*_____

Independent variable _____*Variety of pepper (green or red)*_____

3. Using the theoretical results given in the table below calculate the concentration, in %m/m, of capsaicin in red variety of pepper to the right number of significant figures. *3 marks*

Pepper	Mass of evaporating dish (g)	Mass of evaporating dish and sample (g)	Mass of sample (g)	Mass of evaporating dish and dried filtrate (g)	Mass of capsaicin (g)	Concentration of capsaicin %m/m
Red	49.04	51.03	*1.99 g*	49.12	*0.08*	*0.08/1.99= 4% 1 sig fig.*

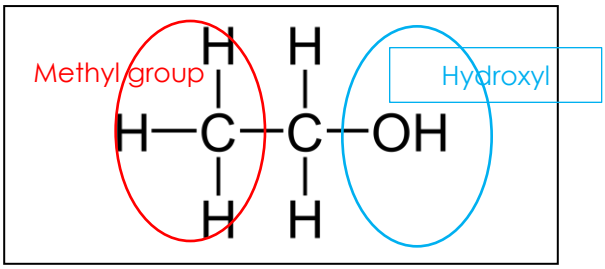
4. Capsaicin is a non-volatile compound with a boiling point of around 210 ^{o}C which undergoes thermal decomposition at temperatures close to 200 ^{o}C.

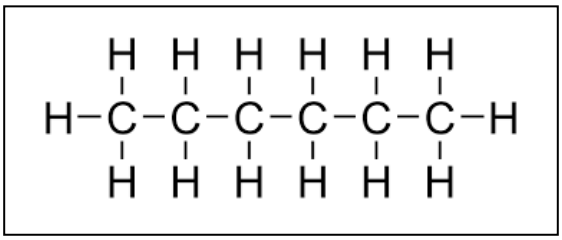
i. Suggest why steam distillation and fractional distillation techniques are not used to purify capsaicin but rather solvent extraction is the preferred purifying technique? *2 marks*

Steam distillation is applicable to volatile non-polar compounds, Capsaicin is not a volatile compound. ---- 1 mark
Fractional distillation, although not on the course but was discussed in our notes, is a method that uses very high temperatures and as such will thermally decompose capsaicin. ---- 1 mark
Hence solvent extraction is the most preferred technique even though the ultimate purity is not guaranteed.

ii. Suggest how the validity of the results can be improved by using hexane as opposed to ethanol. Refer to chemical structure and intermolecular bonding in your answer.

4 marks





Ethanol is a polar molecule that has a hydroxyl and a methyl group. It can dissolve both polar and non-polar molecules. ------ 1 mark

The methyl group will interact via dispersion forces with non-polar molecules whilst the hydroxyl group (-OH) interacts with non-polar molecules via dipole-dipole or H-bonding. ----- 1 mark

Since it can act as a solvent for both polar and non-polar molecules the filtrate will be contaminated with polar molecules as well as non-polar molecules. So we are not measuring the mass of capsaicin only, hence the results for the concentration of capsaicin are invalid. ---- 1 mark

Hexane on the other hand is a non-polar hydrocarbon and will selectively dissolve non-polar compounds only. This increases the selectivity for capsaicin. ---- 1 mark.

5. Capsaicin is the main ingredient in pepper spray. Its chemical structure is shown in fig. 1.

   The chemical structures of casein, a protein found in milk as well as a fat storage molecule, triglyceride also found in milk, are both shown in fig 2.

   General advise for the treatment of capsaicin in the eyes is to rinse the eyes with water for 30 minutes and if possible wash with milk. Given that capsaicin is a relatively non-polar molecule discuss the mode of operation by which water and milk interact with capsaicin to ease the pain and other physiological impacts of the molecule. Refer to structure and intermolecular bonding. *4 marks*

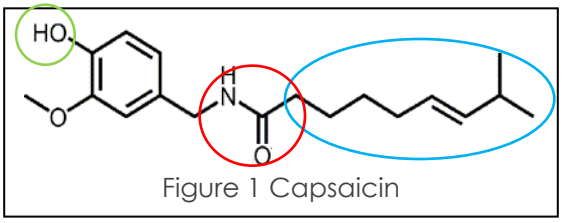
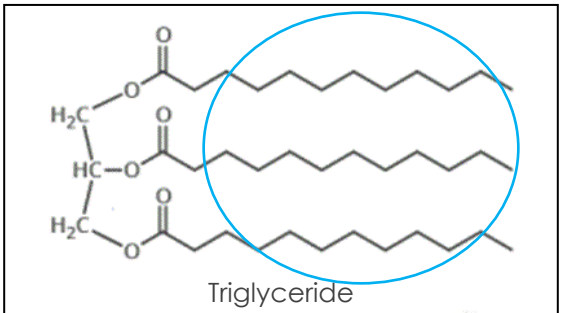
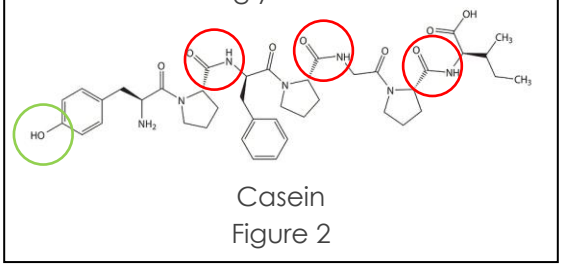


Figure 1 Capsaicin



Triglyceride



Casein

Figure 2

- *Both casein and triglycerides are capable of dissolving and dispersing capsaicin to varying degrees. The large non-polar hydrocarbon chain of capsaicin, circled in blue in fig1 will interact via dispersion forces with non-polar triglyceride fatty chains also circled in blue in fig 2. ---- 1 mark*
- *Casein is a protein and more polar than the triglyceride. Its ability to act as a solvent to dissolve and disperse the largely non-polar capsaicin is limited. Casein will act via hydrogen bonding between the amide groups in casein circled in red and in capsaicin. Other opportunities to form limited hydrogen bonds exist between the hydroxyl groups of both molecules as well, circled in green in fig 1 and 2. ----- 1 mark*
- *Casein, however, has non-polar regions that can interact with capsaicin as well, such as the benzene rings. ---- 1 mark*
- *Water is a polar molecule and as such has limited ability to dissolve and disperse capsaicin. Rinsing offers a physical mechanism to dipserse capsaicin by pushing it away from concentrated regions on the face and eyes where its impact is felt more strongly. ----- 1 mark*