# The importance of structure: chocolate

Your teacher will give you two pieces of chocolate. They are both the same type and the same brand but one has been taken from a bar that was melted and re-hardened in a fridge, whilst the other is from a bar that was stored normally. Before you eat the chocolate note its texture and appearance. Try snapping both samples. When you eat the chocolate, note any difference in taste and texture between the two pieces.

Record your observations.

## Background information

Chocolate is a common confectionery product sold throughout the world. Making chocolate requires the manufacturer to understand how the consumer perceives it and what they like and dislike. The preferred type of chocolate varies from country to country as you will know if you have tried chocolate from the USA (eg Hershey's and Reese's) or from various parts of Europe. Many people from the USA do not like British chocolate, just as many British people do not like the American varieties. Your favourite chocolate is an individual choice but generally the different tastes and uses for chocolate in different countries reflect the history of the chocolate-making industry in those places. In Mexico, for instance, chilli is added to drinking chocolate.

The taste of the chocolate is partly determined by the receipe used to make it but there is more to it than that. You have tried seemingly identical chocolate bars which were made to the same recipe – but they tasted different. This is because the taste of chocolate is dependent on its microscale structure. Chocolate is made up of tiny particles and crystals which range in diameter from 0.01 mm to 0.1 mm. These particles govern how the chocolate is perceived by the consumer. In order for you to taste the flavour compounds in chocolate, they have to reach your mouth and nose. However, the texture of the chocolate is important too. The way you perceive the texture is a result of how the chocolate melts and breaks up in the mouth.

> Ingredients of Cadbury's Milk Chocolate: Milk, sugar, cocoa mass, cocoa butter, vegetable fat, emulsifiers, flavourings.

A key ingredient of chocolate is cocoa butter. Cocoa butter is a fat and it has at least six different crystal forms. This means that the atoms are the same but they are arranged differently. The different arrangements can lead to different properties in the chocolate, including melting point, how easily it snaps, strength, glossiness and texture. You can think of the atoms as being a bit like lego bricks. You can use the same bricks to make different structures – some will be stronger, some will look better.

The ability of a substance to take on many different crystal forms is called polymorphism (poly means many; morph means shape). The details of the polymorphism of cocoa butter are very complex and this is still an area of active research. It is known, however, that one of the six polymorphs has a far superior taste and texture compared to the others – the one known as Form V. Chocolate containing Form V is also the glossiest and snaps well.

The table below shows some of the characteristics of different cocoa butter polymorphs.

| Polymorph | Conditions needed to make the polymorph | Melting point (°C) |
|---|---|---|
| Form I | Rapid cooling of the molten chocolate | 17.3 |
| Form II | Cooling the molten chocolate at 2 °C | 23.3 |
| Form III | Solidifying the molten chocolate at 5–10 °C or storing Form II at 5–10 °C | 25.5 |
| Form IV | Solidifying the molten chocolate at 16–21°C or storing Form III at 16–21 °C | 27.3 |
| Form V | Solidifying the molten chocolate while stirring it. Requires a special process called 'tempering' | 33.8 |
| From VI | Storing Form V for four months at room temperature | 36.3 |

1. Why are chocolate manufacturers keen to ensure that their chocolate contains mainly Form V cocoa butter?

.....

.....

2. What is the difference between Form V and all the other forms?

.....

.....

3. How could you test the two types of chocolate you tasted at the start to see if they contain Form V? Write a plan and get it checked by a teacher before you carry it out.

.....

.....

.....

## Your results

Record your results clearly in a table. Draw a graph of your results for each chocolate sample.

4. Which (if any) of your chocolate samples contains Form V cocoa butter? Explain your reasoning.

.....

.....

5. Which form(s) do you think the other sample contains? Explain your reasoning.

.....

.....

6. How could chocolate manufacturers remove Forms I–IV from their chocolate without removing any Form V crystals?

.....

.....

7. Why is knowing about structures important to chocolate manufacturers?

.....

.....

## Extension question

Some students report that the pre-melted chocolate has a stronger chocolate flavour than the regular chocolate. Can you explain why that might be?