Why does chocolate snap?

Learning Objective

To understand how the six different crystalline forms of cocoa butter affect the textural qualities of chocolate.

Group Activity

Time to complete

- 30-45 minutes

Procedure

1. Take 100g of non-tempered chocolate made with the MacIntyre at Abertay (it looks all bloomed and crumbly).
2. Crumble it up and add to a glass bowl (diameter 12 cm) .
3. Place in the microwave for 1 minute and 10 seconds (full power). Stop and mix for a minute then return to the microwave for a further 10 – 20 seconds until temperature is above 45 ^{0}C (avoid going above 50^{0}C if possible as this spoils the milk chocolate).
4. Divide the mixture in half and carry out on each half one of the following treatments:

   CONTROL – NON-TEMPERED

   Mould and put straight into the fridge (non-tempered chocolate). Label up the mould with the condition and your name.

   TEMPERING THE TRADITIONAL WAY BY TEMPERATURE ONLY

   Cool the chocolate to 26 -28^{0}C (place dish over a bowl of cold water) centigrade then return to 29-31 ^{0}C (by placing dish over a bowl of hot water) then mould and put into the fridge (tempered the traditional way). Label up the mould with the condition and your name.

   TEMPERING BY SEEDING WITH COCOA BUTTER

   Add 1% cocoa butter seeds (grate the coca butter) about ½ a ½ teaspoon when the temperature of the chocolate is at 32^{0}C, then mould, then put in the fridge . Label up the mould with the condition and your name.

   Add 1% of tempered cocoa butter seeds (grate the tempered cocoa butter) about ½ a ½ teaspoon when the temperature of the chocolate is at 32^{0}C, then mould, then put in the fridge . Label up the mould with the condition and your name.

TEMPERING BY SEEDING WITH COMMERCIAL PRE TEMPERED CHOCOLATE

Add 15 g of grated commercial chocolate to the chocolate straight after you have removed it from the microwave . Check the temperature of the chocolate is between 28-33^{0}C , then mould, then put in the fridge . Label up the mould with the condition and your name.

5. Take the samples out of the fridge and observe the snap and shine.
   What crystalline form is the cocoa butter of the chocolate sample likely to be in ?
   Extension: How is tempered cocoa butter made ?
6. Please clean up for the next group.

Equipment and ingredients

- Approx. 12 cm bowls for melting the chocolate
- large bowls for cooling down the chocolate if necessary .
- Thermometers
- ½ teaspoons
- Chocolate moulds
- Labels
- Pens
- Spoons and knives
- Chocolate non-tempered (this can be prepared in advance by heating and cooling without tempering).
- Milk chocolate commercial
- Cocoa butter
- Microwave

The Science

Chocolate is a complex mixture of compounds derived primarily from cocoa beans, the seeds of the Theobroma cacao tree. The main components of chocolate include cocoa solids, cocoa butter, sugar, and sometimes milk solids, depending on the type of chocolate.

Theobromine, a stimulant like caffeine, is also present in cocoa solids and gives chocolate some characteristic effects. The key to chocolate's unique texture and mouthfeel is cocoa butter, a fat composed primarily of oleic, stearic, and palmitic acids.

From a chemical perspective, chocolate is a fascinating example of how molecular structure and arrangement can dramatically influence a substance's macroscopic properties. The interplay between cocoa butter crystals, sugar crystals, and other components creates the complex sensory experience we associate with high-quality chocolate.

Chocolate Structure

Chocolate's unique properties and texture are largely dependent on the crystalline structure of cocoa butter, the primary fat in chocolate. Cocoa butter is polymorphic, meaning it can crystallise into six forms, labelled I through VI, each with distinct characteristics (Table 1).

Table 1 . The different crystalline forms of Cocoa Butter

Crystalline form. Type :	**Melting point (^{O}C)**	**Tasting notes**
I	17.3	Soft and crumbly
II	23.3	Crumbly
III	25.5	Firm but melts easily
IV	27.3	Slightly more firm but melts easily
V	33.8	Perfect for chocolate. Nice snap and shine.
VI	36.3	Too hard

The most desirable crystal form for chocolate is Form V. This structure gives chocolate its glossy appearance, firm texture, satisfying snap when broken, and smooth melt-in-your-mouth sensation. Form V crystals have a melting point of about 33.8°C, which is just below body temperature, allowing chocolate to melt pleasantly on the tongue.

To achieve the ideal Form V crystallisation, chocolatiers use a process called tempering. This involves carefully controlling the temperature to manipulate the cocoa butter crystals. The process typically starts by melting the chocolate completely to destroy all existing crystal structures. Then, the chocolate is cooled to around 27-28°C, where both Form IV and Form V crystals begin to form relatively quickly (KET FACT: The V form crystals start forming below 33.8 ^{0}C but near to the MPT crystalline formation is slow) . Finally, it's reheated slightly to melt any undesirable Form IV crystals, leaving only Form V seed crystals.

As the tempered chocolate cools, the Form V seed crystals act as templates, promoting the formation of more Form V crystals throughout the chocolate. We can speed up this seeding process by adding already formed V crystals to the chocolate at the desired tempering temperature . This can be done either with previously successfully tempered chocolate or tempered cocoa butter. This seeding process at the right tempering temperature for the desired crystalline form can proceed relatively rapidly.

Overall results despite which process is chosen the results are a uniform crystalline structure that gives properly tempered chocolate with its desirable qualities. Without proper tempering, chocolate may develop a dull appearance, soft texture, or even a greyish "bloom" on the surface due to the formation of less stable crystal forms or the transformation of Form V to Form VI over time.

Fat or Sugar Bloom

Fat bloom is a common issue in chocolate that manifests as a whitish or greyish coating on the surface. This phenomenon occurs when chocolate is exposed to temperature fluctuations, causing the cocoa butter to separate from the other components. As the chocolate warms, some of the cocoa butter melts and migrates to the surface. When it cools and recrystallises, it forms a visible layer that gives the chocolate a dull, streaky appearance. Fat bloom is often a result of improper tempering during production or poor storage conditions, such as keeping chocolate in warm environments or subjecting it to temperature shocks.

Sugar bloom, on the other hand, is characterised by a white, dusty, and grainy coating on the chocolate's surface. This type of bloom is caused by moisture encountering the chocolate. When moisture interacts with the sugar in chocolate, it dissolves the sugar crystals on the surface. As the moisture evaporates, the sugar recrystallises, forming larger crystals that create a rough, dusty texture. Sugar bloom can occur due to storage in humid environments, condensation forming on chocolate when it's moved from cold to warm areas, or the use of hygroscopic ingredients in chocolate production.

Both types of bloom affect the appearance and texture of chocolate but do not render it unsafe for consumption. Fat bloom typically feels smooth and melts when touched, while sugar bloom has a grainy texture and doesn't melt easily. To prevent fat bloom, chocolate should be properly tempered and stored in a cool, stable environment. For sugar bloom prevention, chocolate should be kept in dry conditions and protected from moisture exposure.

Sensorial Qualities of Chocolate

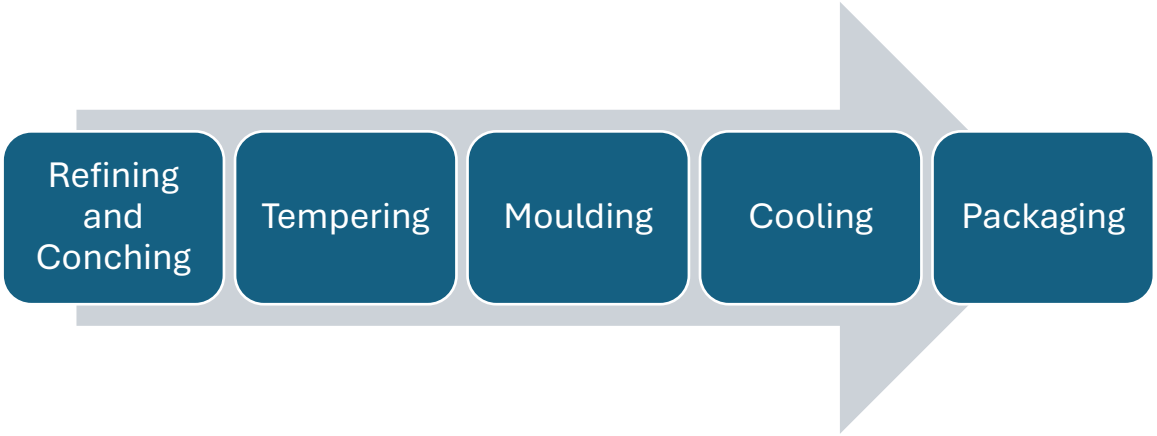
The sensory qualities of chocolate are a complex interplay of various factors that engage multiple senses, creating a rich and multifaceted experience for consumers (see figure 1. The visual aspect is the first to be noticed, with high-quality chocolate exhibiting a glossy surface and a deep, rich colour ranging from light brown to nearly black, depending on the cocoa content. When broken, well-tempered chocolate produces a satisfying snap, which is not only audible but also felt through the hands, indicating proper crystallisation of cocoa butter.

Upon tasting, chocolate's sensory profile becomes even more intricate. The flavour is a balance of sweetness, bitterness, and sometimes acidity, with undertones that can include fruity, nutty, or even floral notes depending on the origin and processing of the cocoa beans. The mouthfeel is equally important, with the ideal chocolate melting smoothly on the tongue due to cocoa butter's unique melting point being just below body temperature. This creates a pleasant cooling sensation as it liquefies, coating the palate with its rich flavours. The texture should be smooth and free from graininess, with any added ingredients like nuts or fruits complementing rather than detracting from the overall sensory experience. These combined qualities contribute to chocolate's widespread appeal and its status as a beloved confection worldwide.

Figure 1. The chocolate wheel created at Abertay University by their Trained Chocolate Panel (2017).

Appendix

Process for Making Chocolate



The MacIntyre Refiner/Conche