Key Stage 3 Worksheet

The Science of Baking

Open the file in your web browser to click on the links.

Baking is often thought of as a fun, creative activity with tasty treats at the end. But when you look beyond getting experimental with flavours and decorating techniques, baking is as much a science as an art. From the ingredients you use, to how you mix them, so many factors determine whether you'll get the perfect cake, or a hot mess.

What words would you use to describe a perfect cake?

Ingredients

The ingredients in a cake have different roles which can be split into three categories. They can be structural agents, leavening agents, or shortening agents. Each ingredient in a cake will have one, or more, of these roles.

Structural agents – give your cake structure, usually by making large protein networks.

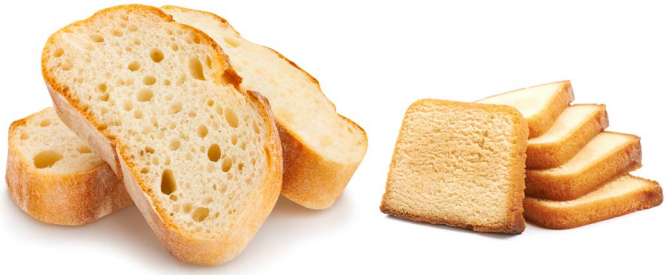
Shortening agents – stop the protein structures in your cake getting too long; they are what keeps your cake soft and moist.

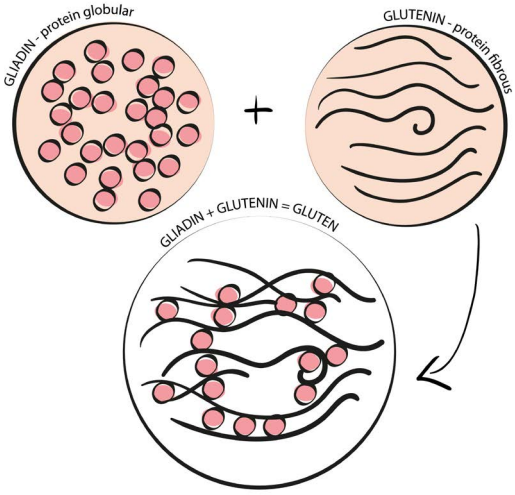
Leavening agents – these add air bubbles into your cake and make it spongy.

Flour

Flour provides structure. When we bake, we usually use wheat flour which contains the proteins **glutenin** and **gliadin.** These proteins are made from quite small molecules but when they are mixed with water, they change shape and join together making a large, elastic protein network called gluten. Gluten can stretch and has pockets that can trap air and other molecules, such as starch. Learn more about gluten **here.**

Not all wheat flours have the same amount of these proteins. For example, bread flour contains more glutenin and gliadin than the plain or all-purpose flour used for cakes. This is what makes the texture of bread different to the texture of cake.





Gluten is a protein of the cereals

In fact, not all cakes contain gluten. You can use flours that are not made from wheat to create gluten-free cakes. These flours contain the carbohydrates, such as starch, that your cakes need but since they will not form gluten when mixed with water you will need to add another protein source. Another protein source could be gelatin or agar-agar, which will create an elastic structure similar to gluten.

Look at the descriptions of the common cake and baking ingredients below and fill in the gaps to say if you think the ingredient is a **structural, shortening** or **leavening** ingredient.

Flour is an example of a _____ agent.

Bonus activity!

SEEING GLUTEN

Want to see gluten in real life? Make a simple dough ball by combining flour and water.

You will need:

- One or more types of flour (e.g. plain flour, bread flour, wholemeal flour)
- A bowl
- A large spoon
- A sieve

Method

1. Put 100g (or about 1 cupful) of one type of flour into a mixing bowl.
2. Slowly add about 50ml (or about half a cupful) of warm water to the flour, mixing constantly, until it starts to stick together as a dough.
3. Mix the dough with your hands for about 5 minutes. You can do this in the bowl or on a clean, flat surface. You are aiming for a soft dough - if it's too sticky, add a little more flour, or if it is too dry, add a splash of water.
4. Put your dough ball in a sieve and place under a running tap to wash away the starch.
5. When the water runs clear you'll be left with gluten. How much did you get? Try stretching your gluten. Is it stretchy or brittle? Do you think using different flour will give different results?

Write or draw your results here.

Eggs

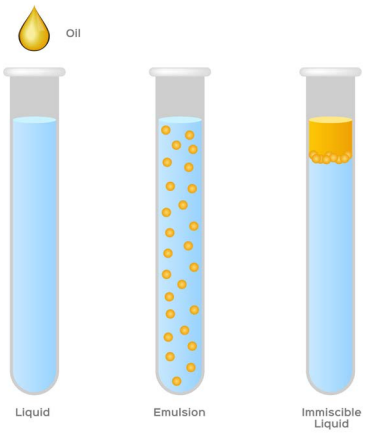
Inside an egg there are two parts - the yolk, and the white. The white is made up almost entirely of protein, but the yolk contains nutrients and fats. There is roughly twice as much white as yolk. The whites and the yolks play different roles in baking.

The whites can be whipped to make a foam. This foam contains millions of tiny bubbles of air that expand when heated during baking. If we did not want to use the foam in a cake, we could whip it with sugar and something acidic, like cream of tartar, to stabilise it. This is how meringues are made. Learn more about acids **here.**

This foam is created because of the structure of the proteins in the egg whites. Egg whites contain globular (round) proteins that have both hydrophilic and hydrophobic parts. This means the proteins have parts that like water (hydrophilic) and parts that don't like water (hydrophobic). When these proteins are in water, they fold into a ball with the hydrophobic parts in the centre, away from the water, and the hydrophilic parts on the outside, in contact with the water.

When you whip the egg white you begin to pull the protein balls apart exposing the hydrophobic sections to the water. They don't like to be near the water, so they surround themselves with a cushion of air. When the protein sections join back together, the air becomes trapped inside as lots of tiny bubbles.

Emulsion



Egg yolks contain fat which adds flavour to your cake, but they also play an important role in the structure. Egg yolks emulsify the ingredients. This means they make the fats and water-based ingredients mix well together. This makes the mixture homogeneous - all parts of the batter are the same. If your batter is homogeneous, the cake will have the same taste and texture all the way through.

Bonus activity!

EXPLORING EMULSIFIERS

Want to see this in action? Try this activity to see which household products can act as an emulsifier.

You will need:

- Some empty jars or small bottles with screw-top lids
- Cooking oil
- 2 small bowls
- Spoons
- A raw egg
- Some other household products, for example sugar, laundry detergent, flour, milk
- A funnel

Method

1. Use a funnel to pour about 1cm (centimetre) of water into each of your bottles or jars.
2. Pour the same amount of cooking oil into each of your bottles or jars.
3. Put the lids on all of your bottles or jars and make sure they are screwed on very tight!
4. Shake each bottle/jar for 5 seconds.

Draw or write what the mixtures inside the jars look like.

5. Leave the bottles/jars to stand for 5 – 10 minutes.

Draw or write what the mixtures inside the jars look like now.

6. Take the egg and break it above a bowl. Separate the yolk from the white by passing the egg between the two halves of the eggshell. The white should drip into the bowl or beaker while the egg yolk should stay in the shell you are holding.
7. Place the egg yolk into a different bowl.
8. Use a spoon to break the egg yolk and mix it for a few seconds.
9. Open the lids on all of the bottles/jars.
10. Put a spoonful of egg yolk into one of the bottles/jars and a spoonful of egg white into another bottle/jar.
11. In each of the remaining bottles/jars, add a spoonful of a different household product (for example, sugar, flour, milk, detergent). Keep track of what is in each bottle/jar.

What household products are you using?

12. Put the lids on all of your bottles or jars and make sure they are screwed on very tight!
13. Shake each bottle/jar for 5 seconds.

Draw or write what the mixtures inside the jars look like.

14. Leave the bottles/jars to stand for 5 – 10 minutes.

Draw or write what the mixtures inside the jars look like now.

15. If the water and oil stay mixed together and don't separate, the added ingredient is acting as an emulsifier.

Which of your household products acted as an emulsifier?

The proteins in the egg yolk unfold and stick together. This allows them to act like glue in a cake and also provide structure.

Egg whites are a _____ agent, while egg yolks are a _____ agent. When you are baking, you can add a whole egg to get the benefits of both the white and the yolk. However, if you separate the egg first, each part will perform its role even better!

Sugar

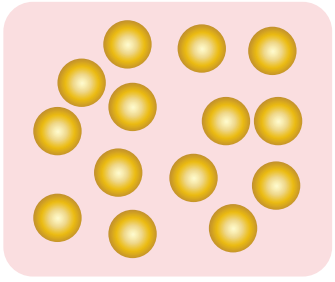
Sugar makes cakes sweet, but this is not its most important role in your cake; it does so much more.

Sugar effects the texture of a cake. It makes strong bonds with water which keeps cakes soft and moist. This stops your cake drying out too quickly. Its strong bond with water also takes water away from the proteins in flour which stops the gluten network becoming too strong. If the gluten network became too strong your cake would be chewy.

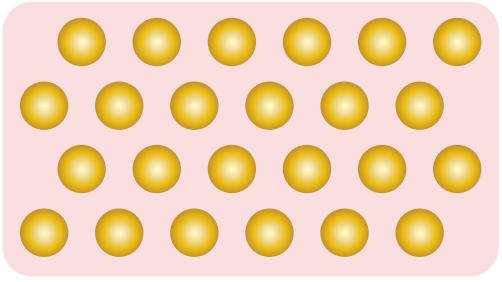
Sugar can also be used as a _____ agent.

The technique you use to mix it with butter causes the sugar to cut into the butter, creating pockets of air which expand during baking. This happens because of the shape of the grains of sugar. Their atoms are arranged in regular patterns called crystals, so we say the sugar has a crystalline structure. These crystals can have sharp edges.

Solid Crystal Structures



Amorphous Solids



Crystalline Solids

Sugar Crystals

Bonus activity!

GROW YOUR OWN SUGAR CRYSTALS

Want to learn more about the crystalline structure of sugar? Try growing your own sugar crystals.

This activity uses boiling water. **Ask for permission from an adult before trying this activity.**

You will need:

- 1 cup of boiling water
- 3 cups of sugar
- A clean glass jar
- A pencil or butter knife
- A piece of string or a wooden skewer
- A bowl
- A spoon
- Paper towels
- Food colouring (optional)

Method

1. Very carefully pour the boiling water into a bowl.
2. If you are using food colouring, add a few drops to the water.
3. Add the sugar to the bowl, one spoonful at a time, and stir the mixture until all of the sugar has dissolved. If the sugar won't dissolve, heat the mixture in a pan or in the microwave (ask for permission from an adult to do this).
4. Leave the mixture to cool for a few minutes.
5. Carefully pour the mixture into your jar.
6. If you are using a wooden skewer, place this into your jar. If you are using string, tie one end to the middle of a pencil or butter knife, then place the pencil or butter knife on top of the jar so that the string dangles into the mixture.
7. Put a paper towel over the top of the jar to keep your mixture clean.
8. Leave the jar to stand for a few days.
9. Pull the wooden skewer or string out of the jar.

Write what has happened.

Butter

Butter and other solid fats help to keep the cake tender by shortening the strands of gluten. This is because fats are hydrophobic (they don't like water) so when flour is coated in a fat, it is harder for the water to get to the proteins (glutenin and gliadin) in the flour. This makes it harder for gluten to form.

Butter is usually used in baking more than other fats because it also adds flavour to our food.

Butter and solid fats are _____ agents.

In fact, solid vegetable fat is usually called shortening.

Try it at home

MAKE YOUR OWN WATERPROOF SAND

Learn more about hydrophobic materials by making your own waterproof sand.

Click here to find out how!

Baking soda & baking powder

Both of these ingredients are _____ agents. They are used to create air bubbles, which expand while baking, making the batter rise.

Baking soda is sodium bicarbonate. It is an alkali, so when we use it in baking, we also need to add an acid to our recipe. The alkaline sodium bicarbonate will react with the acid - we call this a neutralisation reaction. During the neutralisation reaction, bubbles of carbon dioxide are released into the batter.

Baking powder already contains both an acid and an alkali. It is a mixture of sodium bicarbonate (alkali) and cream of tartar (acid). When baking powder is added to water, the acid and alkali can mix, creating a neutralisation reaction.

When the cake is heated during baking, these gas bubbles expand causing the cake to rise.

Take it further! Want to learn more out acids and alkalis check out our video **here.**

Word search

Complete the sentences below and find your answers in the grid.

A	D	I	U	G	S	B	Q	O	L	G	F	H	P	E
I	D	A	F	U	E	C	U	A	N	N	L	U	N	F
Z	B	O	G	B	V	S	R	T	I	I	O	X	J	Y
L	T	A	S	T	O	U	U	I	T	N	U	L	N	V
I	R	E	H	G	T	S	L	R	J	E	R	C	U	O
K	I	H	Q	C	N	J	V	T	P	T	R	Z	V	Q
O	K	B	U	T	D	I	F	B	M	R	V	R	N	X
J	A	R	Y	Q	O	I	K	K	I	O	K	J	X	D
D	T	W	Q	Q	X	X	P	A	V	H	O	R	N	N
S	L	K	B	U	A	P	D	B	B	S	B	J	O	X
N	H	Y	L	E	A	V	E	N	I	N	G	M	R	H
W	F	F	V	F	M	U	J	W	R	W	E	O	S	S
A	A	K	P	S	K	L	I	F	S	G	G	E	V	J
R	E	D	W	O	P	G	N	I	K	A	B	C	R	M
X	L	B	L	R	K	R	J	V	G	J	Z	H	C	H

1. A _____ agent makes cakes rise.
2. _____ contains the proteins glutenin and gliadin.
3. _____ and solid fats are _____ agents.
4. _____ have 2 parts the yolk and the white.
5. _____ _____ is usually used when recipes contain an acid ingredient such as lemon juice.
6. _____ _____ contains an acid and alkali and undergoes a neutralisation reaction on contact with water
7. _____ has a crystalline structure.
8. _____ agents form large protein networks to provide cakes with structure.

Baking activity

S4 CAKE RECIPE

Let's put everything we've learned into practice by making our own cake!

This activity uses an oven. Ask permission from an adult before starting this activity.

Ingredients

- 100g Butter
- 100g Caster Sugar
- 2 Eggs
- 100g self-raising flour
- ½ teaspoon baking powder
- ½ teaspoon vanilla essence
- 1 tablespoon milk

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Method

1. Heat oven to 190C/fan 170C/gas 5. Butter one 20cm round cake tin and line with non-stick baking paper.
2. In a large bowl, beat the caster sugar and butter together.
3. Add the eggs and vanilla essence and continue beating.
4. Add the flour, baking powder and milk beat until your batter is smooth.
5. Pour the mixture into the tins.
6. Bake for about 20 minutes until golden.
7. Turn onto a cooling rack and leave to cool completely.

Get experimental

Try changing the ingredients in the recipe above. You can either change the quantity of the ingredient (for example, use more flour) or substitute the ingredient for something else (for example, use vegetable oil instead of butter). See what happens to the taste and structure of your cake. Use the table on the next page to record your observations.

Record your observations

What did you change?	What happened?

This is a bit like when we do experiments in the lab. The ingredient you change is the independent variable. What happens to the cake is the dependent variable. To make sure our experiment is reliable, we must only have one independent variable at a time and everything else must stay the same. The things that stay the same are known as control variables.

Look at the words you used at the start to describe a perfect cake. Which of your recipes created the best cake?

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