

Chocolate cake in a mug

Focus group: This experiment can be done with groups of any age and the theory can be adjusted to the level of the age group.

Length: 45–60 min

Motivation: Examining the phenomena of everyday chemistry using food as a context. Why is baking powder used in baking? What is the function of flour in cakes? What about eggs?

Aim: The aim is to do a molecular gastronomy experiment and understand the chemistry behind it.

Key words: Molecular gastronomy – Excitement – Everyday chemistry

SAFETY AND WASTE DISPOSAL

- This experiment is not to be done in the laboratory!
- The mug is hot when it comes out of the microwave! With small students the teacher should provide necessary assistance, when transporting the hot mug.
- Biowaste should be sorted in the biowaste container and empty food cartons should also be sorted accordingly.

INTRODUCING QUESTIONS

Why is baking powder added to the batter when making cakes and pastries?

Baking powder makes the batter raise and thus soften the final composition. Baking powder consists of a base (sodium bicarbonate) and a slow-reacting acid (disodium pyrophosphate, $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$) that react with each other when baking powder is dissolved in water. The reaction produces carbon dioxide gas, which makes small gas bubbles in

the batter. Chemical reactions occur faster at higher temperatures, so the rising of the batter speeds up in the oven.

The reaction that occurs is the following:



acid + base → carbon dioxide + water + salt

Why is baking powder added to the batter when making cakes and pastries?

Eggs contain protein. During heating, egg proteins are denatured, which means their three-dimensional shape breaks down and the proteins stick to each other. This results in solidification of the cake batter and formation of a cake.

Why is flour added to the batter when making cakes and pastries?

Flour contains starch and its function is to give the cake a solid structure. As the water warms up, the kinetic energy of the water molecules breaks the hydrogen bonds between the starch molecules. As a result, water enters starch grains, which means that the starch grains swell and form new types of hydrogen bonds with water. This creates a three-dimensional network, and the structure becomes more rigid.

BACKGROUND

This experiment is an example of a molecular gastronomy experiment. Molecular gastronomy tries to understand the science behind cooking. In molecular gastronomy we study the chemistry behind food, conduct experiments related to food and taste the foods that we have prepared.

In this experiment you will prepare a chocolate cake in a mug. A chemist sees the cake as consisting of gas bubbles enclosed within a protein network. The bubbles must be small, numerous and the surrounding network of proteins must be resilient in order to keep the structure firm. Once the bubbles are made into the cake batter, protein and starch are added for structure. The final structure is formed in the heat of the oven, or in this case the microwave.

REAGENTS

- Flour
- Baking soda
- Sugar
- Cocoa powder
- An egg
- Cooking oil
- Milk

EQUIPMENT

- A microwave
- A microwave safe mug
- A teaspoon
- A tablespoon
- A fork

INSTRUCTIONS (FOR TWO SERVINGS)

1. Mix 2 tablespoons of flour, a pinch of baking powder, 2 tablespoons of sugar and 2 tablespoons of cocoa powder in a microwave safe mug.
2. Add an egg, 1 tablespoon of cooking oil and 1 tablespoon of milk. Stir well with a fork.
3. Heat the mug in the microwave at full power for 1 minute. If the cake does not look ready, put it back in the microwave for about 10-20 seconds. Be careful with the hot mug!
4. Now the cake is ready to be enjoyed!

CONCLUDING QUESTIONS

When the cake was in the microwave, vapour came out of it. Where did the vapour come from and what was it?

The vapour from the cake is water vapor. The water vapor comes from the egg and milk, which contain water.

What happens to the volume of the cake when it is baked? Why?

The volume increases. When heating the batter, the acid and the base in the baking powder react with each other, and gaseous carbon dioxide is given off in the reaction.

Why were milk and cooking oil added to the batter? What about sugar?

Milk and cooking oil make the cake moister and soften the structure. Sugar sweetens the cake.



EXTRA INFORMATION

When all ingredients have been added to the mug, the batter is loose in structure. When the batter is heated in the microwave, carbon dioxide gas is released from the reaction between the acid and the base in the baking powder. Small bubbles of carbon dioxide form all over the batter and the batter rises. As you continue to heat the mixture, starch in the flour and the egg proteins will deform and the batter will become firmer as the cake cooks. Finally, the water evaporates, and the cake is ready to eat!