FOOD, COOKING AND STEM

A selection of simple experiments using food items, kitchen equipment, cooking processes, and STEM.

Kitchen Gadgets

SCIENCE ON STAGE EUROPE

Content

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About us

Science on Stage Europe brings together science teachers from across Europe to exchange best practice and teaching ideas and concepts with passionate colleagues from over 30 countries. Science on Stage Europe believes that the best way to improve science teaching and to encourage more schoolchildren to consider a career in science or engineering is to motivate and inform their teachers. The non-profit organisation was founded in 2000 and reaches 100,000 teachers Europe-wide.

Credits

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Cover illustration by Gabriela Coelho and Kristina Dovalova

HEATH AND SAFETY

Due caution should be taken with all recipes in terms of cleanliness when dealing with food that is to be consumed.

In addition, particular care should be taken when using hot ovens or hobs, when adult supervision is appropriate.

Content

Contents

Foreword

In our 5th booklet in the series of "Food, Cooking and STEM", we are looking at the science behind several items and implements that aid our cooking skills. It has been said that our kitchens are science laboratories, that specialise in experiments with food and cooking. Our glass beakers are replaced with pans, our measuring cylinders with jugs, our Bunsen burners with blow torches.

We can compartmentalise our lives without realising the interconnectivity between almost all disciplines, especially at schools where the focus can be on exams rather than the great spectrum of our experience.

In modern times technology now plays a much more significant role in our kitchens with microwaves, air fryers, electric food processors, bread makers etc. The list is endless. Some understanding of the science behind them cannot be undervalued.

Thanks to those who have contributed, and suggested ideas for the booklet we hope it is a useful resource in years to come.

David and Rute

[Food, Cooking and STEM booklets]

Knife, Fork and Spoon

Science: Pressure, stability, images

AGE RANGE

5-18 years old

SCIENCE PRINCIPLE

Pressure applied by a solid object
Centre of mass and equilibrium
Images in curved mirrors
Forces and friction

EQUIPMENT/MATERIAL NEEDED

- Knives
- Forks
- Spoons
- Something to cut (e.g. an apple)
- Cork
- Matches

The Science behind the gadgets

Knives

What does sharpness mean? A sharper knife has a smaller area on the cutting edge , and the smaller the area will create a greater pressure, making it easier to penetrate for example an apple or potato.

Forks

A balancing toy can be made using two forks and a cork into which the prongs of the fork are inserted. Correctly assembled the centre of mass is below the balance point creating a stable structure.

Spoons

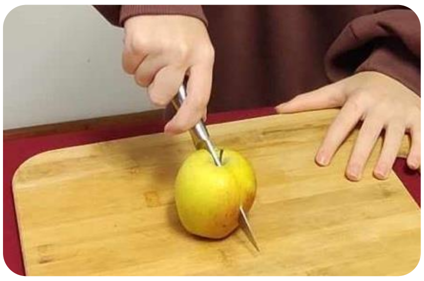
A spoon is like a curved mirror, but with different curvatures depending on how it's held. It can also be concave and convex. Check out the images of your own face! Can you determine the radius of curvature by experimenting.

The friction between the spoon and face creates enough force to hold the spoon. Children can have a lot of fun with several spoons. (NB Wash the spoons thoroughly after this experiment before use!!)

Ideas for experiments

Knives

A simple way to change the cutting area of a knife is it turn it over and present the sharp edge to an apple and feel how easy it is with the sharp edge on the apple compared with the other, unsharpened edge. In that way other variables are kept the same.



Cutting apple with sharp edge.



Attempting to cut the apple with the blunt side of the knife.

Forks

Forks are used in this experiment as they can be easily attached at an angle to the cork and matches used as legs for a simply "human like" object. The weight of the arms of the forks lowers the centre of mass below the point on which the model balances. When the model is rocked it returns to the stable equilibrium position. What else could you make with everyday items?

Spoons

Looking into opposite sides of a spoon creates different images, as we are looking into a convex and concave mirror. You can try with different spoons, e.g. soup spoons and teaspoons as well as dessert spoons as long as they are clear and smooth. Some soup spoons are nearly part spherical, i.e. just one curvature, but most spoons have different curvatures when held upwards or sideways.

Here is a short English poem David was taught when he was young, (a long time ago)

"Before I eat my pudding, I often look to see,
If someone in my pudding spoon is really truly me.
For up and down I look so thin and sideways I'm so fat
I don't believe it's possible that I should look like that".

A second fun thing with spoons is to use the small amount of friction to hold the spoon on your face. The curvature of the spoon is key to holding the spoons in position.

How many spoons can you attach to your face at the same time?

Contributor: David Featonby (UK)

Photographs: Claudia and Diana Meirinhos (Portugal)

Levers and kitchen tools

Science: Moments, principle of levers

AGE RANGE
5-18 years old
SCIENCE PRINCIPLE
Moments
Principle of levers

EQUIPMENT/MATERIAL NEEDED
Kitchen tools representing different types of lever, e.g.
- Scissors
- Nutcracker
- Sugar tongs or tweezers

The Science behind the gadgets

Children like to look at real life applications of the physical rules

1.  2.  3. 

First order levers

In this type of lever the pivot (or fulcrum) is between the effort and the load as in the simple scissors (Figure 1) where the effort and load are similar.

Second order levers

In this type of lever, the load is between the effort and the pivot (or fulcrum) the effort and the load as in the nutcrackers (Figure 2), or garlic press where the load is much greater than the effort...in order to crack the nut or squeeze the garlic.

Third order levers

In this type of lever effort is between the load and the pivot (or fulcrum) as in the pair of tweezers or sugar tongs (Figure 3) where the effort is more gentle than the load applied.

These scissors demonstrate all three classes of levers:

4. All three classes of levers

Levers and kitchen tools

Science: Moments, principle of levers

Ideas for experiments

- Have a selection of kitchen instruments on display and determine the position of load, efforts, and fulcrum and hence to which order of levers each belongs.
- What other things can you find to demonstrate the different levers?

Here is a selection of household levers, can you recognise them?


5. Tongs


6. Bottle opener


7. Corkscrew


8. Egg scissors to remove top


9. Garlic press


10. Chicken stripper


11. Tongs for meat


12. Nutcracker


13. Pastry mould

Which order of levers is being demonstrated in each case? Can you show the positions of the pivot, load and effort?

And finally in the bin. The bin lid is raised using the principle of moments but is there more than one set of levers working in this case. Work out where the forces are acting and which order.


14. Bin

Contributors: Kristina Dovalova (Slovakia), David Featonby (UK)

Electric Kettle

Science: Boiling point and convection currents

AGE RANGE
5-18 years old
SCIENCE PRINCIPLE
Boiling point
convection currents

EQUIPMENT/MATERIAL NEEDED

- Electric kettle
- Water
- Ways to measure water amounts

The Science behind the gadget

An electric kettle is a kitchen gadget designed for heating water quickly and efficiently. It operates on the principle of electric resistance heating.

To heat, the kettles have an electrical resistance that is made of materials such as iron-chromium-aluminium alloy (Fe-Cr-Al) and nickel-chromium alloys (Ni-Cr). The electrical resistance of a conductor is influenced by its resistivity, length, and cross-sectional area.

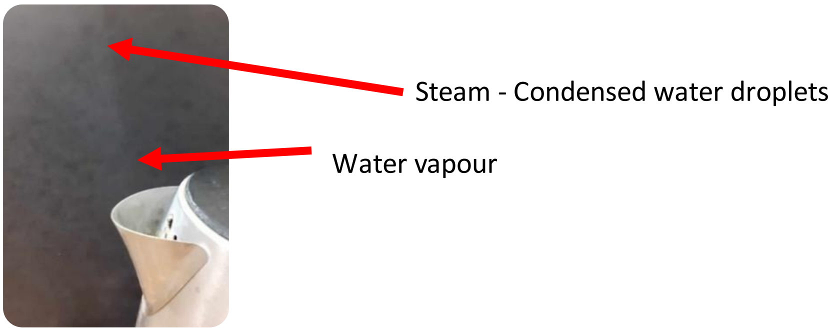
As the element heats up, it transfers this heat energy to the surrounding water. The heat causes the water molecules to gain energy and move more rapidly, eventually reaching the boiling point. Once the water reaches its boiling point (usually 100 degrees Celsius at standard atmospheric pressure), it starts to convert into steam. This process is called vaporization.

The electrical resistance is at the bottom of the kettle so that it can heat the water evenly. Water, which is a fluid, is heated by convection currents.

Convection currents are the movement of masses of a fluid, such as water, due to differences in density. Hot water is less dense than cold water, causing hot water to tend to rise and cold water to tend to go down. Thus, when using a kettle, the heating element is at the bottom heating the water which rises as it gets hotter.


Convection Current

The water vapour at >100 °C is invisible, and we only see the “steam” once the water vapour has condensed into water droplets.



Ideas for experiments

Boiling time vs. volume:

- Measure and record the time it takes for the electric kettle to bring different volumes of water to a boil (e.g., 250 mL, 500 mL, 1 litre).
- Analyse the data to observe any trends in boiling time relative to the volume of water.

Efficiency comparison:

- Compare the energy consumption of the electric kettle with heating water on a stovetop using a regular pot.
- Measure and record the time taken and energy used for both methods.

Link to a video with an experiment showing convection currents:

https://youtu.be/LwLUFUplk0g?si=DwfJlgntvOJuZ6o

Contributor: Rute Oliveira (Portugal)

Toaster

Science: Electrical resistance, heat capacity and albedo

AGE RANGE
11-18 years old

SCIENCE PRINCIPLE
Electrical resistance
Heat capacity, Albedo

EQUIPMENT/MATERIAL NEEDED
- Toaster
- White and brown bread

The Science behind the gadget

How does a toaster heat our bread?

The heat generated in the toaster is an example of the Joule effect, where electrical energy is converted into heat when electric current passes through a conductor with resistance. The Joule effect is a physical phenomenon in which the passage of electric current through some medium results in its heating. This heating arises because of the various collisions that occur between the electrons and the atoms that constitute the crystal structure of the material. For there to be dissipation of energy by the Joule effect, it is necessary that the medium that is crossed by the electric current presents some electrical resistance, which is the ability that the material has to oppose the electric current.
Nickel (Ni) and chromium (Cr) alloys, such as Nichrome, are widely used in electrical resistances due to their high resistivity and stability at high temperatures. They are often used in heating appliances such as toasters, hair dryers and ovens.
The electrical resistance depends on the material, but also on its geometry, that is, it depends on its length and thickness. The longer and thinner the conductive wire, the greater its electrical resistance.

Why doesn't bread toast evenly over time?

Bread contains water. The water present in the bread must be evaporated before roasting reactions can begin. This means that some of the heat supplied is initially used to evaporate the water from the bread. This delays the onset of chemical roasting reactions. The water reduces the effective temperature on the surface of the bread thus delaying the roasting process. Therefore, initially, the water content is much higher, and the bread does not darken as soon as it begins to dry the chemical reaction that occurs during roasting is very fast. Thus, the bread does not darken linearly, it remains much longer clear and when it begins to darken this process is much faster.

Toaster

Science: Electrical resistance, heat capacity and albedo

Why does whole wheat bread toast faster than white bread?

During heating there is a reaction between the proteins and the sugar present in the bread, which is known as the Maillard reaction that produces the typical flavour of toasted bread and is responsible for its brownish colour. Because whole wheat bread contains more sugar than white bread, it undergoes Maillard browning faster than white bread.

In addition to this reaction, albedo also plays an important role here. Whole wheat bread is darker so has a lower albedo[1]. The lower the albedo, the less the surface of the bread reflects the radiation, so the more it absorbs. So whole wheat bread, because it is darker, absorbs more radiation from the toaster toasting faster than white bread.

Ideas for experiments

Resistance and heat – Experiments about Joule effect

You can make a simple demonstration of the Joule effect using a 9 V battery, a little steel wool scrubber and two electrical wires. Connect the end of each electrical wire to one of the poles of the battery. Place the steel wool scrubber in a place where flame propagation cannot occur (on some non-flammable material). Touch the ends of both wires to the steel wool scrubber, closing the circuit and establishing the passage of electric current. This electric current heats the steel wires by Joule effect and, because they are very thin, they become incandescent and catch fire.

Warning: This demonstration should take place away from any flammable material and should be conducted by an adult.

Heating water in a paper cup

Is it possible to boil water in a cardboard cup?

If we heat a cardboard cup in the flame of a candle, we know that it will combust, however if the cup has water this does not happen. Water has a high thermal mass capacity and absorbs energy by heating it to the boiling point of 100 °C. As long as there is water in the cup the temperature of the card does not increase more than 100 °C because during boiling the temperature does not change. The vast majority of the cardboard only combusts at a temperature higher than 200 °C, so the water in the cup prevents the temperature from reaching this value preventing it from burning.

Warning: When performing this activity in the classroom take all the necessary care with flame handling. Choose a cardboard cup that does not have a double bottom.

Albedo experiment

To test the effect of the colour of the bread on the speed with which it is toasted a very simple experiment with 2 equal jars, one painted white and the other black. Place the jars simultaneously in the sun and record the temperature every 10 minutes. Instead of 2 lass jars, you can also use a black plasticine ball and a white one.

Contributor: Rute Oliveira (Portugal)

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[1] Albedo is the proportion of incident radiation that is reflected by a surface.

Baked Potato Rack

Science: Conductivity

AGE RANGE
5-18 years old

SCIENCE PRINCIPLE
Conductivity

EQUIPMENT/MATERIAL NEEDED

- Baked potato rack/conducting rods such as large steel nails
- Potatoes

Potatoes on conducting rods ready to be placed in oven for baking.

The Science behind the gadget

Potatoes baked in a conventional oven or on a campfire are cooked through by conduction. The time of heating depends on the size of the potato and the conductivity of the potato itself. Since we prefer large baking potatoes it can take a longer time to cook the potato to perfection! However, we can speed up the cooking time using this “baking potato rack”. The four prongs are metal with good conductivity and so conduct the heat through to the centre of the potato. Of course, you don’t need to buy such a rack, simply go to the garage, and borrow 4 large steel nails (but make sure they are clean before you start cooking!). Simply cover the skin with butter and place in a hot oven.

Ideas for experiments

You can compare the cooking of potatoes in this way with cooking in a microwave. Certainly one difference will be the skin which will be nice and crispy from the conventional oven and soft from the microwave.

Also compare different sized potatoes when cooking in boiling water. Small pieces will cook much more quickly because the heat has less distance to travel to all parts of the vegetable.

Contributor: David Featonby (UK)

Pancake and Waffle Makers

Science: Conduction

FOOD, COOKING AND STEM

AGE RANGE
5+

SCIENCE PRINCIPLE
Conduction

EQUIPMENT/MATERIAL NEEDED

- Waffle or pancake maker (or similar appliance)


These "machines" are often found in hotels where customers serve themselves at breakfast time.

Kitchen waffle maker showing deposit of mixture and final product after cooking.



The Science behind the gadget

The principle in all these machines is that of conduction by contact.

The pancake maker is a continuously moving belt of conducting material which presses together the pancake mix as it travels. The mix is dropped onto the moving belt which travels under a second similarly moving belt. Both belts heat the mix they are in contact with changing a runny fluid into the solid pancake which drops off the end onto the dish below.

Pancake and Waffle Makers

Science: Conduction

The waffle and doughnut makers consist of two heated shaped plates which are brought together above and below a mix, again to heat from above and below. The slight difference is in the mix which now contains a rising agent, (releases carbon dioxide) so the ingredients together rise in the "machine". So larger machines have a facility to turn so that top and bottom are "more evenly cooked". It is usually up to the cook to remember to open these before the doughnuts or waffles are overcooked!

Usually, the plates are made of fairly thick coated copper to maintain an even temperature over the whole of the waffle/doughnut.

1.

2.

Pictures: Mixture is deposited and then enters under the roller (figure 1 and 2)…

3.

4.

Pictures: … to be cooked before it is dropped out onto the plate (figure 3 and 4).

Contributor: David Featonby (UK)

Pressure Cooker

Science: Boiling point at different temperatures

AGE RANGE
11-18 years old

SCIENCE PRINCIPLE
Boiling point at different temperatures

EQUIPMENT/MATERIAL NEEDED

- Pressure cooker

The Science behind the gadget

The pressure cooker is used to cook food in water more quickly.

The pressure cooker increases the internal pressure and makes it possible to boil the water above its boiling point, which is 100 °C. This is due to the fact that it has around its lid a rubber that seals, that is, prevents the total escape of steam, which in turn is controlled by a hole in the centre of the lid. On top of the hole is a weight, which is responsible for controlling the pressure.

The pressure cooker was invented by the French physicist, Denis Papin. It started out as a scientific instrument but is widely used today in our kitchens.

The boiling point of the water drops by about 1 °C for every 294 m of altitude, so on Mount Everest, the boiling temperature of the water drops to 70 °C. In these places of high altitude, the pressure cooker is an aid in the kitchen, as it allows to compensate for the lower atmospheric pressure in these places.

Ideas for experiments

Use a plastic syringe, add very hot water (slightly below boiling temperature), cover the end of the syringe to prevent air or water from entering or escaping. Pull the plunger of the syringe, increasing the volume inside the syringe, which causes the pressure inside to decrease. Check that the water, at this low pressure, will boil again, but at a lower temperature.

https://youtu.be/a2ldWYRZnig?si=e0prj59o78H3Is95

https://youtu.be/jCylAKH-P5I?si=E_hJBhobUlsLADxB

Contributor: Rute Oliveira (Portugal)

Submerged Egg Timer

Age Range
15-18 years old

Science Principle
Pressure
Boiling Point
Proteins and denaturation

Equipment/material needed

- Eggs
- Submerged egg timers, e.g. BeepEgg

Novelty egg timers which are submerged with the egg are said to guarantee your eggs are cooked to perfection. By starting both your eggs and the egg timer at the same temperature, the temperature inside the egg is monitored so that the alarm sounds when the egg is either soft boiled, medium, or hard boiled.

The Science behind the gadget

Eggs are liquid at room temperature, solidifying irreversibly when heated. Heating causes the denaturation of proteins. The unwinding of proteins exposes the amino acids, allowing new rearrangements through the formation of weaker bonds and generating zigzag structures, this process being called coagulation.

Due to its composition, the coagulation temperature of the egg white is ~60ºC while that of the yolk is ~68 °C.

During the cooking of the egg, it is necessary to coagulate the white and, depending on the taste of each one, the coagulation of the yolk. Some people like more liquid yolk, and others prefer a solid yolk. To do this, it is necessary that the inside of the egg reaches certain temperatures. What these submerged egg timers do is constantly measure the temperature of the water since they are placed in the pan along with the eggs to be cooked. It is with this data that the egg timer is able to know the temperature reached inside the egg. As we know the coagulation temperature of the white and yolk, through a differential equation the egg timer can know at what temperature the entire egg is.

The advantage of these submerged egg timers is that as they do not work based on cooking time, but on temperature, we can use it in any situation, that is, we can start cooking the egg with water at any temperature and the altitude at which we are does not affect the performance of this gadget.

When the egg reaches the right temperature for the required level of hardness, the egg timer plays a song, indicating the specific degree of doneness the egg yolk has reached at that time.

Ideas for experiments

Since the boiling temperature is affected by the altitude at which we are, it may be interesting for students to measure the boiling temperature of water in the place where they are and compare it with the 100 °C that is described in their textbooks, but which refers to places where the atmospheric pressure is 1 atm. They can also find a strategy for measuring boiling temperature of water in different locations around the world, for example asking the teacher to contact schools at very different altitudes who are interested in sharing their results.

Whenever we talk about eggs, we always remember experiences like egg drop experiment, unbreakable egg (we put a lot of weight on eggs and they don't break), walking on Eggs, bounce egg (when you put the egg in vinegar for a while) and many more that you can consult in the booklet in this series on the theme of experiments with eggs, “Eggs-Experiments”!

Almost unbreakable egg

Possible further investigations:

- Does pH affect the denaturation temperature?
- Does salt affect the denaturation temperature?

For example, eggs can be broken into water with a little vinegar, heated and then you can measure the temperature at which denaturation occurs. Repeat by adding a little bicarbonate of soda. Repeat by adding salt to the cooking water.

Contributor: Rute Oliveira (Portugal)

Boiled Eggs

About egg timers

Traditional egg timer

Colour coded egg boiler indicator showing colour change

In the past the time taken to boil an egg to the correct texture, (soft, medium or hard) was determined with a traditional egg sand timer. The amount of time was set by the amount of sand and the size of the hole. For example, the timer shown had a run time of 3 minutes.

This unfortunately takes no account of the size of the egg or the initial starting temperature.

The next step is a simpler timer based on similar principles to something like the BeepEgg, but with no sound. The egg is constructed so that there is a colour change as the parts of the artificial egg reach a certain temperature. Thus, for soft boiled eggs only the outer edges of the artificial egg change colour, but as the heat is passed into the egg the medium range changes etc…

The next step is the "egg boiler" (see our first booklet) where not only is the egg size is taken into consideration but also the number of eggs. Different amounts of water used enable the eggs to be hard boiled, medium of soft. Surprisingly, less water is used for a greater number of eggs. The egg boiler "pings" when all the water in it is boiled away, however the first amount to evaporate condenses on the egg and must be re-boiled, thus it must be boiled twice. Larger eggs will have more water condensing on them, which compensates for the longer time required to cook the eggs.

Eggs and Small cup to measure water.

Contributor: David Featonby (UK)

Candy Floss Machine

Science: Melting point of sugar, circular motion forces

AGE RANGE

3-18 years old

SCIENCE PRINCIPLE

Melting point of sugar
Circular motion forces

EQUIPMENT/MATERIAL NEEDED

- Candy floss machine
- Sugar
- Sugar Thermometer

Candy Floss machine showing heated hopper in the centre where sugar is deposited.

The Science behind the gadget

Candyfloss begins as solid sugar, which is poured into a little hopper with a heating element. Surrounding the mouth of the hopper is a ring pierced with tiny holes; surrounding plastic receptacle to hold the strands of sugar once they are ejected. As the heating element melts the sugar into a liquid, the whole thing is spun. Strands of liquid sugar, not easily visible to the naked eye, shoot out of the hopper onto the container. There, it is flung by the force of the spin through the tiny holes, emerging onto the other side as a bunch of nearly invisible threads which become visible as more and more come together.

The process within the candy floss maker: crystals to candy floss threads.

While the mass of sugar starts out molten, being split into so many little pieces gives it much greater surface area than before – much more of it is exposed to the cooler air – and so it goes from being liquid to being solid in an instant. The resulting sugar cobweb collects all around the inside of the container.

The science doesn't stop here as it is commonly said that these thin strands "melt" in your mouth as you eat the candy floss. But is that correct? Melting is of course used incorrectly because what is happening is that the sugar strands dissolve in your mouth. The thinness of the strands makes it easy for the sugar to dissolve very quickly. There is no significant heat exchange as would happen in a "melt"!

Melting in the mouth or dissolving?

The whole sequence is a good example of a chain of "physical changes", all of which could be reversed with physical processes. There is no chemical change in the sequence.

Ideas for experiments

The sugar needs to be raised to approximately 180 degrees to melt so it can be forced out of the small holes in the hopper. A test experiment measuring the temperature of the hopper could verify this.

Contributor: David Featonby (UK)

Popcorn and Heat Transfer

Science: Heat transfer by conduction, convection, and radiation

FOOD, COOKING AND STEM

AGE RANGE
5-18 years old

SCIENCE PRINCIPLE
Heat transfer by conduction, convection, and radiation

EQUIPMENT/MATERIAL NEEDED

- Popcorn kernels
- Microwave popcorn
- Microwave
- Frying pan with lid
- Stove
- Air popper
- 3 tablespoons of olive oil and salt
- Gloves and googles

In this tasty experiment we can learn about heat transfer by conduction, convection, and radiation as we pop popcorn in three different cooking gadgets.

The Science behind the cooking process

Part I: Conduction

Heat transfer is conducting through a solid material, in this case through the frying pan. The popcorn is heating up and popping because the heat is transferred by conduction from the stove to the frying pan and from it to the oil and from the oil to the kernels. Stove, frying pan, oil and kernels are in contact.

Part II: Convection

Convection is the direct heat transfer from a fluid. Air is a fluid, so the hot air transfers the heat to the kernels, and when enough hot air heats the kernels, they pop.

Popcorn and Heat Transfer

Science: Heat transfer by conduction, convection, and radiation

Part III: Radiation

Radiation transfers through empty space, it is the main manner in which air is heated by the sun. The kernels are heated by the radiation in the microwave, and the kernels heat up, giving off more heat to the kernels surrounding them until the heat is enough and they pop.

The Science behind the dish

Part I: Conduction

Each kernel of popcorn contains a small drop of water stored inside a circle of soft starch. Popcorn needs between 13.5-14% moisture to pop. The soft starch is surrounded by the kernel's hard outer surface.

As the kernel heats up, the water begins to expand. Around 100 °C the water turns into steam and changes the starch inside each kernel into a superhot gelatinous goop. The kernel continues to heat to about 175 °C. The pressure inside the grain will reach around 9 atm before finally bursting the hull open.

As it explodes, steam inside the kernel is released. The soft starch inside the popcorn becomes inflated and spills out, cooling immediately and forming into the odd shape we know and love. A kernel will swell 40-50 times its original size!

Contributor: Nuria Muñoz (Spain)

Links: https://www.popcorn.org/Learning/Science-Fair-Projects

Microwave and Oven

Science: Conduction and radiation through different materials

AGE RANGE
5-18 years old

SCIENCE PRINCIPLE
Conduction and radiation through different materials

EQUIPMENT/MATERIAL NEEDED

- Microwave
- Oven

The author with his microwave and conventional oven

Mince pies

The Science behind the gadget

Microwave ovens and conventional ovens cook food in different ways. This is an experiment that shows this very clearly.

Particularly over Christmas "mince pies" are popular in England. That is a pastry case containing sweet mince, said by some to represent the manger from the Christmas story! Often these are given to carol singers as they move from house to house in our villages. And because singers have been out in the cold, they mince pies are often served warm. But what is the best way to heat them?

Mince pie showing mincemeat inside.

In a conventional oven they are heated initially by convection of the air in the oven space to the outside pastry surface but then the heat moves into the pie by conduction through the pastry to the mincemeat. So, in the first minute or so the outside is hot, but the mincemeat remains cool.

In a microwave oven the radiation penetrates the pie to the mincemeat which is strongly heated because of its water and fat content, thus in the first few minutes the mincemeat becomes very hot, and the outside pastry remains cool.

After a while the heat is more evenly spread and so the whole pie will be warm.

Another difference will be that the outside of the pastry will crisp up in the conventional oven because it is in contact with the hot air circulating. Therefore, water from the pastry evaporates, whilst the pies in the microwave will have a much softer pastry case. Another interesting piece of physics is that if you take a bite of the hot pies once they are all warmed will be how" hot" the mincemeat feels compared with the pastry, even when they are at the same temperature. This is because of the high specific heat capacity of the mincemeat compared with the pastry.

Ideas for experiments

Videos 28th 29th December 2022; What Happens Next Experiments (Facebook)

Compare the heating of identical food items in both ovens.

A popcorn kernel can also demonstrate our principle. The popcorn kernel contains moisture trapped inside a hard, dry hull. Heating the kernel in oil may burn the outer hull, but not with a microwave. The microwave transfers heat directly to the water molecules in the starch so that the hottest thing the hull touches is the starchy inside. As the water content turns to steam, this "pops" the kernel.

How can microwave ovens e.g. crisp bacon, or brown something on the outside?

Footnote

How does a microwave oven work?

A microwave oven uses a magnetron to create microwaves of a particular frequency (2.45 GHz). These microwaves flip the orientation of water molecules millions of times a second creating the heating effect. They stay in the microwave oven and are either absorbed by the water or reflected by the metal walls of the microwave oven. Microwave ovens do not heat their contents evenly as the microwaves set themselves in standing waves within the oven, (wavelength 12.2 cm) with nodes and antinodes, therefore for a more even distribution of heat a turntable is often used.

Contributor: David Featonby (UK)

Wooden Spoons

Science: Stability, centre of mass, reaction time, free fall, moment of inertia

AGE RANGE
5-18 years old

SCIENCE PRINCIPLE
Stability
Centre of mass
Reaction time
Free fall
Moment of inertia

EQUIPMENT/MATERIAL NEEDED

- Wooden spoons
- String
- Different weights
- Books
- Toilet paper roll

Wooden spoons are found in every kitchen , but how many experiemnts can be performed with them. This is a selection of several short experiments that can be presented , using a wooden kitchen spoon.

1. Balanced spoon (horizontal)

A wooden spoon is balanced with the pivot at its centre of mass. The spoon is then sawn into two pieces at this point and students asked which part is the heaviest. Many students will immediately feel the spoon is balanced between two equal (half) masses, though clearly have missed the point that the moments on either side of the pivot must be equal rather than the masses.

2. Balance spoon (vertical)

A spoon is to be balanced vertically on your hand. Which way round will be most stable, spoon head down or spoon head upwards? The most stable is with the head upwards. Although the turning moment is greater in this position, there is greater resistance to rotation (moment of inertia).

Wooden Spoons

Science: Stability, centre of mass, reaction time, free fall, moment of inertia

Two spoons are now positioned vertically and tilted gently so that they will fall when released. Which of the two spoons will reach the ground first?

The answer is the spoon with the head resting on the table. The reasons are as above.

3. Friction on spoon handle

How many turns of string around a spoon handle are needed to support or to lift a heavy object….? The tension in the string is increased due to the weight below and the number of turns. If the weight is increased so does the tension, and so does the friction. So, the number of turns appears to be independent of the weight (within limits); usually no more than 5.

4. Falling weight with spoon

This experiment of often done with two different weights over a large nail, but a wooden spoon handle is just as good. When the weights are released the string at the smaller weight wraps around the rod. As the string gets shorter the small weight moves faster, and eventually wraps around sufficient times to hold the larger weight.

5. Two spoons falling

Different items fall initially at the same rate (when air resistance is insignificant). Thus, a large and a small spoon reach the ground at the same time when falling the same distance.

There is plenty of opportunity for discussion of Newton's laws here. Also try dropping the two spoons with one held vertically, with less air resistance than one dropped horizontally. (Though over short drops the air resistance is insignificant.)

(use eggs at Easter, and toys at Christmas)

Wooden Spoons

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6. Reaction time

We do not react immediately to an external stimulus, so we need to allow time before any reaction begins. Thus, you can't catch the horizontal rod over the first few centimetres of its fall, so don't try catch it. Lower down when you can, "catch up to the fall" by bending your legs!!

Our reaction time to a visual stimulus is longest because of the route to the brain – via a chemical reaction at the retina. Both touch and sound have a more direct route, so the reaction time is shorter. So, whilst a student may not be able to catch a spoon held vertically and dropped by looking at it, if the student is tapped on the head at the moment the spoon is dropped the chances are that they will be able to catch it.

7. Dropping weights

The end of a toilet roll is held between two heavy books: an example of free fall and weightlessness. Consider the forces acting on each part of the set up. When the books are released the bottom book ceases to exert an upwards force on the paper so there is no "grip", and the paper is released.

Alternative set up shown here with large weights (more spectacular)

8. Bird in the cage

A cage is printed on one side of a spoon, whilst the other side has a picture of a bird. By holding the spoon between the palms of your hands you can rotate the spoon quickly in such a way that the bird appears to be inside the cage. Simply a case of retention of vision.

Contributor: David Featonby (UK)

Fanni Vitkoczi (Hungary)

Notes

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