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Smoothies and shakes

- What do they have to do with chemistry, biology and engineering?

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The experiments of the smoothie project described below show what smoothies, juice and shakes have to do with (bio-)process engineering or chemical and bioengineering.

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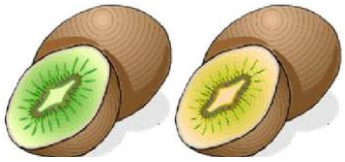
How can kiwis annoy in milkshake?

Questions:

Why can it be problematic to make milkshakes with fresh kiwi? How can dairy products still be made with kiwifruit? Is there a difference between green and yellow kiwis?

You need for the experiment



- one green and one yellow kiwi (golden kiwi)
- 200 ml boiling hot water
- 200 ml milk
- 4 glasses
- 4 teaspoons
- 4 post-Its for labeling the lenses + pen
- 2 boards and 2 kitchen knives
- optional I small sieve (to drain the hot water from the kiwis)
- I Mixer or blender with container
- if necessary, some sugar (for sweetening after the completed experiment)

Implementation of the experiment:

- Label four jars each with: "yellow kiwi fresh + milk", "green kiwi fresh + milk", "yellow kiwi brewed + me" and "green kiwi brewed + milk".
- Peel the kiwis, cut them in half and set one half aside at a time.
- Put the yellow kiwi half in a container with 50 ml of milk and puree it into a shake. Pour it into the labeled jar and wait at least 5 minutes to taste.
- Clean the blender and container very well and repeat the experiment with the green kiwi half. Clean the blender and the container very well again!
- Cut the second halves of the kiwi into as small pieces as possible on two different boards with two different knives. Fill each into a appropriately labeled glass.

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- pour hot water over these pieces in both glasses, let them steep for at least four minutes and carefully drain the water. (If necessary, use a clean spoon or sieve.)
- Puree the brewed green kiwi pieces with 50 ml of milk to make a milkshake and pour them back into their glass.
- Clean the blender with the container and now make the Michshake with the brewed yellow kiwi.
- Now try everything after at least 5 minutes at a time and note the taste.

Evaluation:

Write down what conclusions you can draw from your taste experiences . What answers can you give to the questions asked at the beginning? Research what enzyme reaction takes place in this experiment, or read our explanation.

In conclusion:

Now that you know how to make a delicious kiwifruit milkshake, you can make even more before that . The bitter samples are not harmful to health and can also be drunk with a little sugar so as not to waste food. However, everyone is differently sensitive to bitter substances.

Tip: You can do another exciting experiment with gummy bears and green kiwis. To do this, puree the kiwi and put it in a freezer bag with some gummy bears. In a second freezer bag, add some water with gummy bears.
After a few hours, observe what happened to the gummy bears. This experiment helps to understand how digestion works in the stomach.

Tip 2: If you want to find out more about annoying enzymes, you can find www.kniffelix.de in the Smoothie Mission 11Trial series on green kiwis and pineapples with Milk and oat milk".

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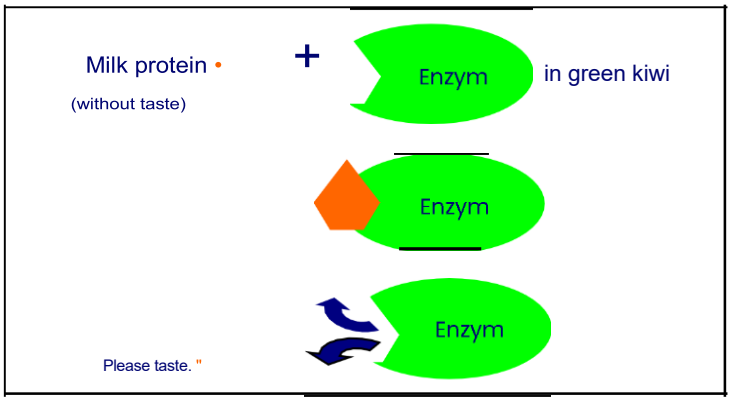
Explanation of the experiment

"How can kiwis be annoying in the milkshake?u

Green kiwis contain the enzyme actinidin, which breaks down proteins, e.g. proteins contained in dairy products. Some of the resulting products taste bitter1, which depends, among other things, on the size of the fragments and their spatial arrangement.



Splitting milk protein by enzymes in green kiwis

Therefore, fresh green kiwis should not be added to desserts or shakes with milk, or consumed before the enzyme has produced too many bitter substances.

Yellow kiwifruit does not contain this enzyme at all, or it has such low activity that these kiwifruit can also be eaten raw with dairy products without a bitter taste2.

In addition to kiwifruit, intolerance to milk can also be observed in pineapples and papaya, because these tropical fruits also contain many enzymes that break down proteins. Depending on the fruit, a different enzyme dominates: actinidine in green kiwi, bromelain in pineapple and papain in papaya. The fact that enzymes break down when they get too hot can be used to use these fruits with milk anyway. If you pour boiling water over kiwis, pineapples and papayas before using them and let them steep briefly, the enzymes will lose their effect!

Tip: By the way, enzymes in these fruits also annoy gelatine! They can prevent gelatine from solidifying or dissolve gelatine that has solidified. Here

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l Source: Wieser, H., Belitz, HD. Relationships between structure and bitter taste in amino acids and peptides II. Peptides and peptide derivatives. Z Lebensm Unters Forch 160, 383-392 (1976). https:/ /doi.org/10.1007/BF01106329

[2] Source: Kaur L, Mao B, Bailly J, Oladeji O, Blatchford P, McNabb WC. Actinidin in Green and SunGold Kiwifruit Improves Digestion of Alternative Proteins-An In Vitro Investigation. Foods. 2022 Sep 6; 11(18):2739. doi: 10.3390/foodslll82739. PMID: 36140865; PMCID: PMC9497782.

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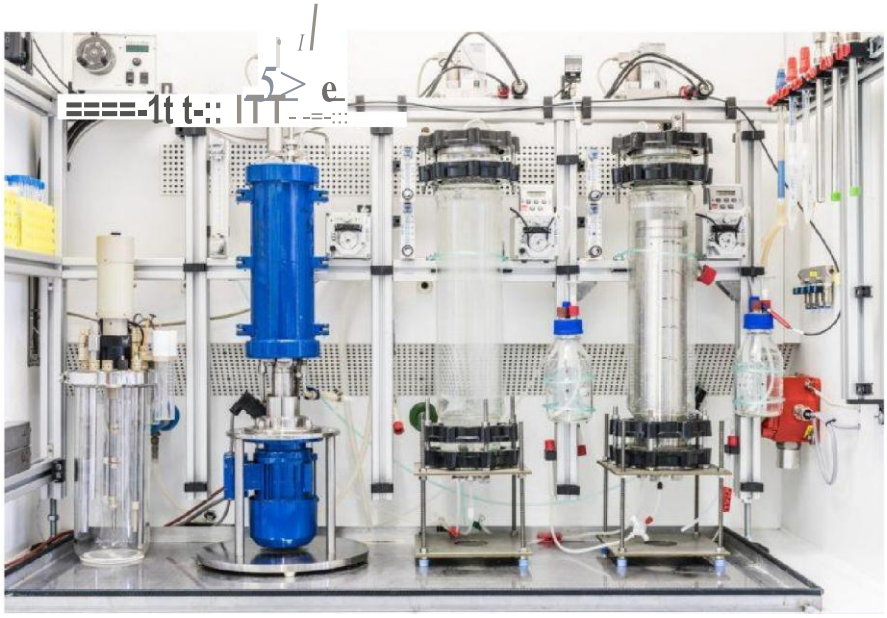
the observations from your experiment help, because here, too, the enzymes can be destroyed by heat by pouring the gelatine over these fruits as hot as possible, and the gelatine becomes and remains solid!

And what does this have to do with bioengineering?

Enzymes are nature's tools for material transformations, so-called biocatalysts. They accelerate reactions at mild temperatures where living things exist and cause fewer by-products than chemical reactions. Therefore, they are also used in industry. Bioengineers are investigating how such processes can be carried out. Since the enzymes are sensitive, it must be investigated under which reaction conditions (e.g. in terms of temperature, pH value) the highest possible yield is achieved and the enzymes remain stable and functional for a long time. The origin of the enzymes also plays a role. If such enzymes are present in bacteria that live in hot springs, for example, then they can tolerate higher temperatures. Bioengineers are also concerned with the selection and size of the bioreactor in which the conversion takes place. Do you need stirrers to ensure good mass transport? Is a gas needed that can provide mixing? How is quality analysed and ensured? These are just a few of the questions that bioengineers encounter in their studies and careers.



Example of an experimental setup from the biotechnologist
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Experimental series on green kiwis and pineapple with milk and oat milk

Dairy products and fruits do not always get along. With these series of experiments, you can find out in which cases problems occur.

You need for the experiments

- 2 green kiwis
- 200 g fresh pineapple
- 50 g canned pineapple
- 700 ml milk (3.5% fat)
- 200 ml oat milk
- a kettle (with temperature setting or additionally a thermometer, suitable for 60 °C)
- 9 glasses
- 9 post-Its for labeling the lenses + pen
- I Hand blender with container
- 2 boards and 2 kitchen knives
- A kitchen scale (or use quantities according to feeling: for pineapples about as much as 1/2 kiwi equals, for milk/oat milk about 1/2 glass)

Implementation of the experiments:

- Label the post-It for the first jar with "Experiment 1: Green kiwi with milk". Then label the other post-Its with the further attempts, as indicated in the bold headings below. Glue the post-Its to the lenses.
- Peel the kiwis and fresh pineapple.
- Read the experiment descriptions carefully: For some experiments, the fruits go directly into the container of the hand blender, for others they must first be prepared with hot water or by boiling.
- Rinse the hand blender and container after each blending for the next attempt.

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- Since you can't do all the experiments at the same time, you should prepare an experiment protocol and take a taste sample of each experiment immediately after it is carried out and 10 minutes later. Also check whether the shake is homogeneous or whether phase separation is taking place.

Experiment 1: Green kiwi with milk

- Add 1/2 green kiwi and 100 ml milk to the container.
- Mix for about 30 seconds with the hand blender and pour the shake into the glass labeled „11Try 1".

Experiment 2: Boiled green kiwi with milk

- Cut 1/2 green kiwi into small pieces on a board with a knife.
- Put the pieces in a glass, pour boiling water over them and let them steep for 5 minutes.
- Drain the water and pour the pieces into the container together with 100 ml of milk.
- Mix for about 30 seconds with the hand blender and pour the shake into the glass labeled „11Try 2".

Experiment 3: Green kiwi warmed to 60 °C with milk

- Cut 1/2 green kiwi into small pieces on a board with a knife .
- Put the pieces in a glass, pour 60 °C hot water over them and let them steep for 5 minutes.
- Drain the water and pour the pieces into the container together with 100 ml of milk.
- Blend for about 30 seconds with the hand blender and pour the shake into the glass labeled „11Try 3".

Experiment 4: Green kiwi with oat milk

- Add 1/2 green kiwi and 100 ml oat milk to the container.
- Blend for about 30 seconds with the hand blender and pour the shake into the glass labeled „11Try 4".

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Experiment 5: Fresh pineapple with milk

- Cut the fresh pineapple into small pieces on the second board with the second knife.
- Add about 50 g of these pineapple pieces and 100 ml of milk to the container.
- Blend for about 30 seconds with the hand blender and pour the shake into the glass labeled "Try 5".

Experiment 6: Boiled pineapple with milk

- Put about 50 g of chopped fresh pineapple in a glass, pour boiling water over it and let it steep for 5 minutes.
- Drain the water and pour the pieces into the container together with 100 ml of milk.
- Blend for about 30 seconds with the hand blender and pour the shake into the glass labeled "Try 6".

Experiment 7: Pineapple warmed to 60 °C with milk

- Put about 50 g chopped fresh pineapple in a glass, pour 60 °C hot water over it and let it steep for 5 minutes.
- Drain the water and pour the pieces into the container together with 100 ml of milk .
- Blend for about 30 seconds with the hand blender and pour the shake into the glass labeled "Attempt 7".

Experiment 8: Pineapple with oat milk

- Add about 50 g of fresh pineapple and 100 ml of oat milk to the container.
- Mix for about 30 seconds with the hand blender and pour the shake into the glass labeled "Attempt 8".

Experiment 9: Canned pineapple with milk

- Add about 50 g canned pineapple and 100 ml milk to the container.
- Blend with the hand blender for about 30 seconds and pour the shake into the glass labeled "Try 9".

Observe how homogeneous the milkshakes are, whether phase separation takes place and what the taste is immediately after the trial and after 10 minutes.

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This is what your still empty test protocol could look like:

Experiment No.	Ingredients	Homogeneous directly after Mixing?	Taste directly after Blend	Homogeneous according to 10 min?	Taste after min
I	Green kiwi with milk				
2	Cooked green kiwi with Milk				
3	Green plants heated to 60 °C Kiwi with milk				
4	Green kiwi with oat milk				
5	Fresh pineapple with milk				
6	Boiled pineapple with milk				
7	Pineapple warmed to 60 °C with milk				
8	Pineapple with oat milk				
9	Canned pineapple with milk				

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Explanation of the experiment "Experimental series on green kiwis and pineapples with milk and oat milk

Surely you have also found the following results after 10 minutes in your attempts:

Trial	Result after 10 min
Experiment 1: green kiwi with milk	bitter, not homogeneous
Experiment 2: cooked green kiwi with milk	not bitter
Experiment 3: green kiwi warmed to 60 °C with milk	bitter, relatively homogeneous
Experiment 4: green kiwi with oat milk	not bitter, not homogeneous
Experiment 5: Pineapple with milk	Very bitter! not homogeneous
Experiment 6: cooked pineapple with milk	not bitter
Experiment 7: pineapple warmed to 60 °C with milk	bitter, relatively homogeneous
Experiment 8: Pineapple with oat milk	not bitter, not homogeneous

So, it turns out that dairy products become bitter after a short time when they are put together with fresh green kiwis or fresh pineapple. The enzymes in the green kiwi or pineapple react with components of dairy products and one of the reaction products tastes bitter.

If, on the other hand, these types of fruit are cooked for 5 minutes, the enzymes are destroyed and the dairy products continue to taste delicious. If these types of fruit are only heated with 60 °C hot water, this is not sufficient to destroy the enzymes.
In fact, the enzyme bromelain, which is responsible for the reaction with dairy products in pineapples, is relatively temperature-stable in contrast to other enzymes in fruit and even has its highest activity at 50 °C. At temperatures above 50 °C, however, bromelain slowly begins to denature. Canned pineapple is used at

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pasteurized, i.e. heated to such a high temperature that the enzymes are denatured and no longer pose a risk of making dairy products taste bitter. There is also no reaction with oat milk, but the mixture has not remained homogeneous in our country.

Why do we keep emphasizing that these trials should be done with green kiwifruit? Give it a try, or watch the experiment "How can kiwis annoy in milkshake?"

And what does this have to do with biotechnology?

Bromelain is not only an enzyme that sometimes annoys in the kitchen, but is obtained as an important raw material and is used in the food industry, cosmetics, dietary supplements and as an active ingredient in medicines. The extraction and use of enzymes is a subfield of biotechnology.

Specifically, bromelain is used to tenderize meat, brew and bake, and produce protein hydrolysates, which serve as a source of protein for athletes, for example. Other applications can be found in the leather and textile industry, in wool production, for skin care and in detergents.

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Mixing and observing smoothies

You need for the experiment

- A blender with a container or a blender
- Any ingredients for a smoothie

Implementation of the experiment:

Take a close look at the blender or blender, then prepare a smoothie and pay attention to how the flow moves, e.g. using small pieces.

Questions to observe:

What did you mix the smoothie with? With a hand blender? Did the hood with the header have holes? Or did you use a blender? Did the mixer just turn everything in circles or were there several streams to be seen?

Read the following text and relate the theory to your observations.

Theory of the experiment
"Mix and watch smoothies"

All the details you could observe about the blender's blades, hood, and flows as you blend are important when making a smoothie, as the device performs two functions at the same time. On the one hand, the fruits are to be crushed, but on the other hand, the crushed fruits are also to be mixed.

If you cut the fruit before blending, then the blade of the knife was certainly pointing in the direction you pressed, right? To chop the fruit when blending or pureeing, it should be enough if the blades

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of the blender or blender. But the blades are angled. Why? If you were to hold the knife at an angle while cutting fruit and press the same way as before, you would push the fruit away on the side with the acute angle (please don't try it, risk of injury if the knife slips off!). Due to the angled blades, exactly the same thing happens in your device. The shredded pieces are pushed away. With the blender, the shredded pieces are pressed into the hood and deflected laterally by the round shape. If the hood has holes on the side, the pureed fruit can flow out of the hood without coming into much contact with the unpureed fruit.

These currents are especially important for the blender, as it has to catch all unpureed pieces by hand without guidance. For this, it is important that the blender ensures a flow through the blades. The flow is usually directed downwards at the blades, is deflected to the walls at the bottom and then goes back up in the middle towards the blades.

What is important in any case is a high speed of the blades and the flow. The high speed means turbulence for the flow. Turbulence is a completely chaotic flow within the main flow. This turbulence is important for mixing the crushed fruit in the smoothie.

And what does this have to do with process engineering or engineering?

Were you interested in the topic of flow control and comminution? Currents are dealt with in the subjects fluid dynamics or fluid mechanics. A suitable course of study could be process engineering or mechanical engineering.

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Leaf Dance

You need for the experiment:

- some tea (loose or from a tea bag) or other small particles that are slightly heavier than water, e.g. chopped fruit or kiwi skins
- Water
- a cup and a teaspoon
- possibly fruits, a blender and container for a smoothie from the experiment

Implementation of the experiment:

Pour some tea into a cup of water and stir with a teaspoon.
Observe how the leaves move in the current, and what happens when you stop stirring. What happens if you don't stir in a circle, but only make movements back and forth with the spoon? How do the pieces settle on the bottom of the vessel?

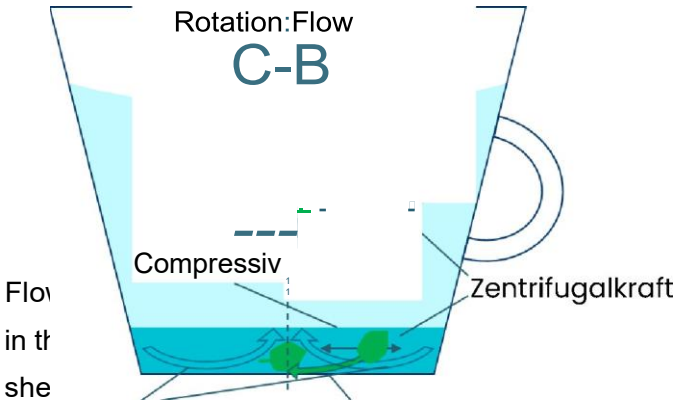
Explanation of the experiment "Leaf Tanzu

Observation:

During stirring, the leaves move like water on circular paths in the cup. When you stop stirring, they sink to the bottom and collect in the middle of the vessel.

Explanation:

During stirring, the centrifugal force is mainly at work, pushing the water and leaves outwards. Since the wall of the cup prevents the tea from moving any distance outwards, an inward pressure is created as a counter-reaction. When you stop stirring, the centrifugal force slowly subsides, so the pressure plays a bigger role. In addition, there is the fact that



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bottom of the cup gives a boundary layer in which the flow is strongly slowed down. Because the bottom of the cup does not move and frictional forces act between the water particles and the ground, they can no longer whiz around there as quickly. So the centrifugal force is much smaller in this layer, but the inward compressive force is the same, so that a total force acts inwards.

You could also simply determine that the water pushed out by the stirring has to return, and therefore the direction of flow at the bottom of the cup is reversed. The water flows inwards with the tea leaves and then rises in the middle of the cup. Due to gravity, the tea leaves do not rise with them, but collect on the bottom.

And what does this have to do with engineering?

Flows play a central role in engineering, especially in fields such as mechanical engineering, civil engineering, process engineering, and aerospace engineering. Here are a few examples:

- To design vehicles, aircraft, pumps, or piping systems, engineers need to understand how liquids and gases flow.
- The forces exerted by currents must be calculated or estimated in order to design structures that can withstand wind and water forces, such as bridges, buildings, and dams.
- In environmental engineering, currents are important, for example, to predict the spread of water and air pollution or to calculate wastewater treatment plants.
- For cooling systems, heating systems and air conditioning systems, heat transfer must be calculated by flows.

Since flow processes can be very complicated, there are various methods and simplifications to find solutions to the problems of practice. This includes , for example, the consideration of boundary layers.

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What do you whip cream with?

Question:

With a hand mixer, there are whisks and dough hooks for different purposes. But what happens when you try to whip cream with the dough hooks?

You need for the experiment

- half a cup of whipped cream (100 ml)
- a hand mixer with whisk and dough hook
- a jar for whipping cream
- possibly. 1/2 tsp sugar

If you have the opportunity to print other stirrers with a 3D printer, you will also need a drill in which you can clamp the stirrers and 2064748 the print files from www.printables.com/de/@NachwuchsCam.

Implementation of the experiment:

(Depending on the equipment and time available, you can only try beating with the dough hooks or carry out a preliminary test or even parallel test with the whisks. Then you will need twice the amount of cream and, if necessary, a second mixer with cup.)

Pour the cream with the sugar into the cream cup and beat it with the dough hooks for several minutes. As you do this, time how long it takes for the cream to stiffen (if it works at all).

Explanation of the cream whipping experiment

When whipping cream, the introduction of air is important. The whisks are better suited for this than the dough hooks. They cause a vortex through which air is introduced into the cream. Due to their larger outer diameter, the speed per revolution is higher and consequently also the shear force that occurs during stirring. This divides the introduced air into very fine bubbles.

Since the cream is thin, it does not offer as much resistance to the stirrers as, for example, a yeast dough. This needs the stronger, slimmer dough hooks.

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Alternatively, a hand blender with a beater disc can be used to whip cream. This is a disc with holes that rotates during operation and generates high shear forces, so that especially small air bubbles form, making the cream firmer and stable for longer.

By stirring, air is whipped into the cream. The proteins in it hold the air in many small air bubbles. Around these bubbles, the milk fat of the cream forms layers that stick together, so that the bubbles do not collapse. This is all the better the colder the cream is (approx. 4 °C is ideal), the higher the fat content and the more "mature" the cream is: It has to be refrigerated for about two days so that the proteins become more elastic and elastic. However, you don't have to worry about that, because it already happens in the dairy.

Also interesting:

- Frozen cream can no longer be whipped, because the ice crystals destroy the structures of fat and proteins.
- In the case of UHT cream (ultra-high temperature cream), the proteins are damaged by heat, so that it can no longer be whipped so well.
- Whipped cream releases unbound water after a few hours, causing it to lose its stand and loose structure. Therefore, binders such as cream stiffener or gelatine are added to cream cakes, which bind the free water. These binders form gels with the water.
- In bakeries and confectioneries, cream is whipped with so-called cream blowers. A compressor blows air into the cream container from below, while at the same time a rotating stirring grid in the container ensures good mixing.

And what does this have to do with process engineering?

When stirrers are used for the large-scale production of chemicals, cosmetics, pharmaceuticals and much more, their selection suitable for the stirring task plays an important role. You can find more information about this in the experiment "Mixing with 3D printing stirrers". As with the cream blower, industrial processes sometimes mix with gases that flow through a liquid. These devices are called bladder columns.

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Mixing with 3D printing stirrers

Question:

What do you use which stirrers for? How does the flow or mixing become visible?

You need:

- a hand or better column drill
- 3D printed stirrers
- a stirring tank
- Alginate or Bubble Tea Pearls
- Sugar
- brown rock candy
- red food coloring (best as a solid paste, e.g. sugar writing)
- Oil, preferably pumpkin seed oil (is very dark, therefore particularly visible)
- Water

You can print the stirrers with a 3D printer. To do this, you need our print files from the 3D printing platform printables: either enter "printables nachwuchscampus" in the search engine and click on the appropriate hit or enter https://www.printables.com/de/@NachwuchsCam_2064748.

Implementation of the experiments:

Gradually clamp the stirrers into the drill and examine the mixing behavior during different stirring tasks. The stirring tasks are

- Suspend (distribute solid in liquid phase)
  → Experiment Ia: Bubble tea pearls in water
  → Experiment Ib: Bubble tea pearls in sugar solution (dissolve as much sugar until they float)
  → Experiment Ic: brown rock candy in sugar solution
- Homogenize (dissolve two miscible phases into each other)
  → Experiment 2: Food coloring in water
- Emulsify (distribute two immiscible liquids into each other)
  → Experiment 3: Oil in water

If you can't do the experiments yourself, watch the videos on the website.

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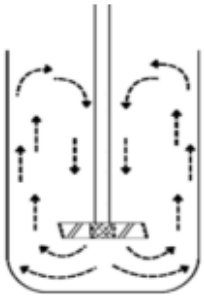
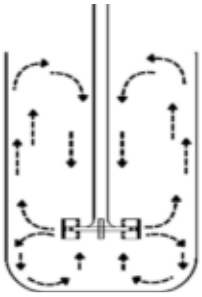
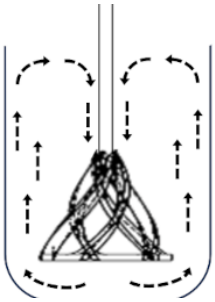
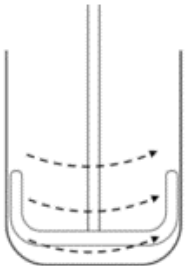
Explanations of the mixing experiment

You can see the four stirrers used with their typical characteristics and areas of application compared here in a table:

	Disc Stirrer	Inclined Blade Stirrer	Spiral stirrer	Anchor Stirrer
	radial	axial	axial	radial
Flow direction				
Position	Far from wall	Far from wall	Near wall	Near wall
Shear rate mixing	high	Medium	Low	Low to medium
Tasks	Aerate,emulsify	Homogenize,suspend	Homogenized,heat transfer	Heat transfer
Typical application	Fermentation,gas introduction	Mixing liquids,solid suspensions	Polymerization,high-viscosity media	Very viscous liquids, pastes

When suspended, the particles usually have a different density than the liquid, so they lie on the bottom first or float on top. The inclined blade stirrer is best suited for mixing, as it causes an axial flow (i.e. up and down). When the particles collide with its leaves, larger particles can be crushed. The spiral stirrer also mixes axially, but much more gently. These two types of stirrers are also suitable for homogenizing.

The disc stirrer is more likely to be used for emulsification, often with several discs that are distributed over the height of the reactor. It has a high shear rate, which means that high forces occur on the outer edge of its blades, which crush the oil or fat droplets and distribute them in the aqueous phase (or, conversely, the water droplets in the oil phase).

Often, flow breakers are also used, which are tripping thresholds on the reactor walls, so to speak, that prevent the flow from simply flowing in a circle along the outer wall.

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The secret of the blueberry shake

You need:

- 100 g blueberries
- 100 ml milk
- a hand blender
- a suitable container

Implementation of the experiment:

Puree the blueberries with the milk and watch what happens.

Explanation/Considerations of the Experiment

After pureeing, the drink quickly turns into a pudding-like mass that no longer tastes delicious.

The cause must lie in a reaction of components of blueberries and milk. Blueberries contain a lot of pectin, which can swell strongly (bind water).

You may know pectin from making jam. Pectin is a preserving sugar, and the mixture is heated so that the jam becomes firm. Pectin belongs to the carbohydrates, i.e. to the macromolecules that are made up of sugars. When pectin meets protein, e.g. milk protein, pectin-protein complexes are formed. Especially in the acidic pH range, the electrostatic attraction of oppositely charged proteins and pectins is promoted.

However, whether this is really the explanation for the test result can be tested with the following experiments:

1. Puree cooked blueberries with milk to make a shake
2. Apple Milkshake

Hypothesis for experiment 1: Since pectins are used to make jam, they should not be affected by the heat of cooking, at most they should be activated

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(unlike proteins, which denature due to heat). If you then cool them down and puree them with cold milk, the same thing should happen as with uncooked blueberries.
Result of experiment 1: A blueberry milkshake with cooked blueberries works very well, tastes very delicious and does NOT gel even after standing for a long time!
This refutes the hypothesis.
Hypothesis for experiment 2: Since apples, like blueberries, contain a lot of pectin, an apple milkshake would also have to gel.
Result of experiment 2: The apple milkshake works and does not gel. It only splits after standing for a long time, but tastes good.
This also refutes the second hypothesis. A simple complex formation between pectins and milk proteins does not seem to explain the phenomenon.

Another assumption is that the tannins of the blueberry (polyphenols) react with the milk protein. Tannins are chemical compounds that form poorly soluble compounds with proteins and other molecules. They can change the structure of proteins, for example by precipitating or cross-linking them. In this respect, this could also be an explanation that could be investigated. However, polyphenols are also not said to be sensitive to heat, so that experiment I cannot be explained with this theory either.

If you have another lead or are conducting experiments that support or disprove hypotheses, feel free to write us a comment on www.kniffelix.de or an e-mail.

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Lemon Magic

Have you ever wondered why an apple or banana turns brown? Imagine you want to make a delicious smoothie for your friends, but after blending, everything has turned brown. „Mist!" you think to yourself. Why is that? Is there a remedy for this? To find out, you start a series of experiments.

You need for the experiment

- 4 glasses
- Sticky notes to label the jars and a pen
- I Knife
- I Cutting board
- I Blender
- 2 apples
- I packet of citric acid
- I Lemon
- I Tablet Vitamin C (Ascorbic Acid)
- 4x 100 ml water (half a glass full each)

Implementation of the experiment:

Label the sticky notes with the planned additions as shown in the image above and stick them to the jars. Cut the apples in half and use one half for each experiment. Cut the first half of the apple into small pieces, put them in a blender with 100 ml of water and puree them for 30 seconds on medium power. Add this first serving to the first glass without adding any other agents. This portion serves as a reference to compare the results from the other experiments.

Now do the same with the other apple halves, but add a different component before mixing: The second portion is accompanied by the squeezed juice of a whole lemon, the third portion is a packet of citric acid and the fourth and last portion is a crushed tablet of vitamin C. After mixing, pour all portions into the appropriate glasses. Now observe: How does the content of the jars change over the course of an hour?

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Explanation of the Lemon Magic Experiment

Apples contain polyphenols **in the cells, more precisely in the vacuoles.** These molecules determine, among other things, the color and aroma of the apple. When the apple is cut open, the cells are damaged, causing polyphenols to escape and come into contact with the air. In addition, the enzyme **polyphenol oxidase** leaks.
This enzyme causes the polarphenols to be oxidized with the oxygen in the air to form quinones, which leads to brown coloration. This natural Protective mechanism prevents microbial infestation, as **quinones** are toxic to microorganisms. Thus, an injured apple does not spoil so quickly, but it no longer looks so attractive.

This enzymatic brown coloration can be prevented by two components present in lemons: citric acid and ascorbic acid (also known as vitamin C). Both substances intervene in the oxidation reaction.

Citric acid hinders oxidation by binding copper ions. These copper ions are important for the function of polyphenol oxidase and are therefore called **cofactors**. Due to the binding of the copper ions, the enzyme cannot carry out the oxidation reaction properly.

Ascorbic acid {vitamin C) prevents enzymatic browning by reacting with the oxygen from the air, thus removing the reaction partner for the polyphenols. In turn, the ascorbic acid itself is oxidized. Enzymatic browning is prevented until all ascorbic acid molecules have been used up.

Food manufacturers use this knowledge to make their products last longer by adding these so-called preservatives in a targeted manner. This keeps the smoothie or fruit salad from the refrigerated section fresh and delicious for a longer time.

And what does this have to do with bioengineering?

Many microbial and enzymatic processes occur in nature. Understanding these is important in order to make use of the principles or to develop countermeasures. Bioengineers research such processes and develop applications. In this way, the knowledge can be used to produce products better or in a more environmentally friendly way. Can enzyme processes be improved? Can undesirable enzymes be suppressed?

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Making Oat Milk

Aim of the experiment

A vegan alternative to milk is oat milk, which is essentially made from oatmeal and water. But subtleties in production influence the result. investigate what the addition of flaxseed does, and find out how the temperature affects the result in the additional experiment.

You need for the experiment

- 40 g rolled oats
- 2 tablespoons flaxseed (crushed)
- 500 ml cold water
- I Tea strainer
- I Hand blender
- I small bowl
- I Mug (large)
- 2 glasses
- I Flashlight

Image 1: By shining the flashlight, the segregation is more visible.

Implementation of the experiment:

Preparation of flaxseed:

Pour the flaxseeds into the bowl. Add 4 tablespoons of water to the flaxseeds and wait 15 min.

Add the oatmeal to the cup. Add 500 ml of water. Puree the oatmeal/water mixture with the wand for 30 seconds. Pour the mixture through the sieve. Pour about 250 ml of the filtrate into the first glass.

Add the flaxseed and water mixture to the other 250 ml of the filtrate. Puree the resulting mixture for 10 seconds. Pour it into the second glass

Stir in both glasses with a teaspoon and observe. X-ray the lenses from time to time with a flashlight.

Additional attempt:

Now do the experiment with oatmeal and water with boiling water instead of cold water. Watch what changes.

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Explanation of the oat milk experiment

Observations

- In the first glass, sediment forms relatively quickly.
- The mixture in the second glass is cloudier.
- In a taste test, the first mixture should taste more watery than the second.

Observations on the additional test

- Much less sediment is produced.
- The mixture is even murkier.
- The consistency is more slimy.

Explanation

Flaxseeds contain natural emulsifiers that stabilize the mixture, so that less sediment forms than with the pure, cold-prepared oatmeal-water mixture. In industry, lecithin or locust bean gum is usually added instead of flaxseed.

Due to the boiling water in the additional experiment, the starch in the oats swells and thus absorbs water. This makes the consistency more slimy. The drink does not taste like oat milk.

And what does this have to do with process engineering?

Process engineering deals with the production and transformation of substances. This also includes separation processes to remove desired substances from a mixture or to remove undesirable ones. The settling of what you observed in the first glass is used, for example, in wastewater treatment or ore extraction. It is also called sedimentation. The sedimentation rate is important for a technical process because it helps determine how long the process takes. It depends on the density of the components, but other properties also play a role, such as the viscosity of the liquid, the size of the particles and the acceleration of gravity. These properties can be influenced by adding substances . Centrifugation, on the other hand, increases acceleration. If you find all this exciting, you could study process engineering.

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What is Process Engineering?

Definition:

Process engineering is the engineering discipline that deals with the development and optimization of processes for material conversion. This changes the composition, type or properties of the substances. This conversion takes place in several steps and can include chemical, physical and biological processes. The aim is to produce products that have specific properties and qualities. A major focus is placed on the efficiency of the processes in order to make them economical and sustainable .

Process flow:

The process of material transformation is typically divided into two main phases: **Upstream processes:** These involve the preparation and treatment of the raw materials. This includes steps such as grinding, mixing, dissolving, separating or generally preparing the starting materials. **Downstream processes:** These include the reconditioning and refinement of intermediate and final products. This includes separation of product mixtures, purification, drying and packaging.

A little more descriptive, please?

The process engineering can be clearly compared to a kitchen or a laboratory. In a kitchen, ingredients (raw materials) are transformed into dishes (products) through various cooking techniques (processes). The individual steps must be precisely coordinated in order to obtain a successful end product. Upstream steps include
e.g. washing and cutting the ingredients while removing downstream, e.g. spice bags, garnishing with chives or simply arranging and serving.
However, an essential aspect of process engineering is the so-called scale-up, i.e. the transfer of processes from small laboratory or pilot plants (private kitchen) to large-scale production facilities (canteen/canteen). This step is particularly challenging because processes do not always behave in a linear manner and require special adjustments to function safely, efficiently and economically on a larger scale.
Process engineering is a key technology that is used in many industries, including chemistry, pharmaceuticals, food technology and environmental technology. It enables the efficient and sustainable production of products that are indispensable in our daily lives.

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Areas of process engineering

1. Chemical Process Engineering

Basic Operations/Tasks:

- Design of reactors
- Development of catalysts
- Determine optimal reaction conditions (pressure, temperature, concentration, reaction time, catalyst, reaction kinetics)

Industrial Applications:

- Synthesis of chemicals (e.g. ammonia synthesis for fertilizers)
- Petrochemicals (e.g. crude oil cracking)
- Production of polymers (e.g. polyethylene and polypropylene)
- Production of fine chemicals and pharmaceuticals

2. Biotechnological Process

Engineering Basic Operations/Tasks:

- Fermentation: Use of microorganisms (e.g. bacteria, fungi)
- Determine optimal fermentation parameters (pH value, temperature, oxygen content)
- Development and use of enzymes for the production of specific products

Industrial Applications:

- Production of antibiotics (e.g. penicillin)
- Production of biofuels (e.g. ethanol, biogas)
- Food industry (e.g. fermentation of dairy products)
- Production of enzymes for detergents

3. Thermal Process Engineering

Basic Operations/Tasks:

- Distillation: Separation of fluid mixtures by different boiling points
- Extraction: Separation of substances by solvent
- Absorption: absorption of gases in a detergent
- Adsorption: Absorption of a fluid on the surface of a solid
- Drying: Removing moisture
- Crystallization: Separation of a crystalline product from a solvent
- Membrane technology: Separation of a fluid mixture by a membrane

Industrial Applications:

- Refining of petroleum and production of spirits
- Extraction of plant extracts
- CO_2 capture
- Activated carbon filter
- Paper production
- Refining of sugar
- Seawater desalination

4. Mechanical Process

Engineering Basic Operations/Tasks:

- Crushing: Reduction of the particle size of solids
- Agglomerate: Merging smaller particles into larger agglomerates
- Mixing: Homogenization of solid, liquid or gaseous substances
- Separation: Separation of solids from liquids or gases

Industrial Applications:

- Mining (e.g. grinding of ores)
- Food industry (e.g. grinding of grain)
- Pharmaceuticals (e.g. tablet production)
- Wastewater treatment

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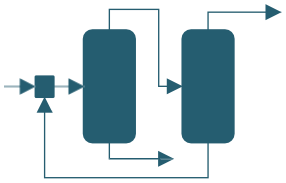

Process Engineering
- A delicious study -

Process Engineering		Kitchen
Raw materials from fossil and renewable sources, e.g. crude oil, natural gas, green waste, sewage sludge, etc.	**Reactants**	Cereals, vegetables, fruit, meat are produced from the supermarket.
Pre-treatment of the reactants, e.g. pre-cleaning, drying, crushing, mixing.	**Deployment**	The fruit and vegetables are washed and peeled, the flour is weighed and the ingredients are mixed together.
Chemical or biological conversion at certain parameters (pressure, temperature, auxiliary materials).	**Reaction**	The yeast makes the dough rise, the oven is set to a temperature and the dish is baked.
Separation of unreacted reactant with return to the reactor (distillation, extraction, absorption).	**Repatriation**	With the vegetable peels and the remaining egg yolk, a dish can still be conjured up wonderfully.
products are freed from impurities and e.g. with filtration.	**Reappraisal**	The vegetable broth is filtered and the noodles .
The products are shaped and packaged into comfortable sizes, e.g. as tablets.	**Packaging**	The cake is cut into pieces and the dish is beautifully arranged on a plate.
The finished product can be purchased in stores.	**Products**	Et voilà! Enjoy your meal!