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Cooking green vegetables in saltwater and at different pH

Do you like your vegetables turn brown during cooking? Various treatments to prevent browning, change of texture and loss nutritional value are investigated.

Aim

Which batch of peas do you prefer?

For us the colour of food is an indication whether the food is fresh or spoiled. As an example we will look at chlorophyll, the green colour of leaves. Fresh green leaves are to us a sign of health – of summer – of youth. Brown leaves appear in autumn and are a sign of age and the first stage of death. The same perception applies to green vegetables. Usually vegetables get brown during cooking – giving the impression, that they are not fresh any more. This heat degradation can not be prevented, but you can alter the colour by manipulation – see the result of the experiment. Often simple chemistry can make the food colour appear more attractive, covering up the fact that the food item actually has lost some nutritional value.

Introduction

Green vegetables turn brown during cooking due to chlorophyll degradation into the brown phaeophytin. Various treatments can not prevent chlorophyll degradation into other compounds. Some treatments like alkaline cooking water is accompanied by loss of nutritional value and change of texture.

Cooking vegetables is a treatment that changes texture from hard to soft. Texture change is due to change in the organisation of plant fibres, among other reasons. This was in former times a sensible way of treating vegetables, since they had a bigger content of fibres compared to today. Modern kitchen prefers to serve the vegetables to be "with a bite". During the heat treatment chlorophyll changes into a brown degradation product i.e. chlorophyll changes into phaeophytin after loss of the magnesium in the centre of the chlorophyll molecule. But the appearence of the brown colour also shows the consumer when the product is overcooked and has lost some nutritional value, since cooking also degrades cell walls and cell membranes, which leads to the loss of valuable cell contents like vitamins and ions leaking into the cooking water.

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The experiment can show us, that there are two colour products deriving from chlorophyll degradation: a brown product in acid solution and a shining green product in alkaline solution. We want to test the chlorophyll colour change during cooking in different pH and apply two other treatments used in common kitchen practice. The experiment can raise a discussion about the possible loss of the nutritional value of cooked vegetables. Furthermore we can evaluate the texture change that occurs with different treatments.

The final question is whether the visual appearance and the actual nutritional state of the product concur.
The use of excessive salt in the cooking water is based on the recommendation of chefs: "It preserves the colour during cooking" they say. A scientific explanation could be that the salt solution extracts water from the cells of the vegetable (– a process called osmosis), thereby concentrating the cell content, which could prevent it from leaking valuable nutrients. But this is just a theory – only studies of molecular gastronomy will give the right answer in the future.

Materials

Needed by each person or group

- Buffers 4, 7, 8 and tap water (do not use deionised water)
- Kitchen salt (NaCl)
- 5 heat resistant 250 mL glass beakers
- 5 other beakers about 100 mL
- Ice cubes from the refrigerator or ice machine
- Big bucket of cold water with ice
- Cooking plate
- Peas, broccoli, spinach, other green vegetables – all fresh
- Spoon
- Heat resistant glove or towel

Other materials

1. Take the 5 heat resistent beakers and mark them with “4”, “7”, “8” and one with “water”, the other one with several spoons of salt “NaCl”.
2. Fill the appropriate solution into each beaker (about 100 mL).
3. Put the beakers on a hot cooking plate and wait until the content boils.
4. While waiting prepare your vegetables, 5 equal portions.
5. Turn down the heat and add equal amounts of green vegetable to the boiling solutions.
6. Let it simmer for 10 minutes, then take the vegetables out of the water with a spoon and put them in empty beakers and place them immediately in a bucket of water with ice cubes.

7. Do not discard the cooking water; it is essential for the evaluation.
8. When the vegetables are cooled down, place them on equally marked white paper sheets or plates.

Results

- Measure the pH of the cooking water.
- Evaluate the colour of the cooking water.
- Evaluate the colour of the vegetables.
- Evaluate the texture by gently squeezing them with your fingers.
- Write your findings in a table like the one below.
- If possible take pictures of the results.

Conclusions

What are the results?
Describe both the actual data and what you personally think about the results. Cooking books often give advice how to treat vegetables. In fact the treatment with salt is according to a chef's advice. Discuss the treatment described in cooking books and compare it to your findings.

Template for registering the results

Treatment	Buffer pH 4	Buffer pH 7	Buffer pH 8	Tapwater	Saltwarter
pH before cooking					
pH after cooking					
colour of cooking water					
colour of vegetable					
texture of vegetable					

Guide to the protocol:

The influence of pH and salt on the colour and texture of cooked vegetables

Green vegetables turn brown during cooking. Various treatments to prevent browning, loss nutritional value and change of texture are investigated.

Discussion

- Judgement of the colour of the vegetables: which treatment gives the most agreeable green colour?
- Judgement of the cooking water: the darker the colour, the more the vegetables have lost chlorophyll and other valuable nutrients – what is best?
- Judgement of the texture of the vegetable: the best texture feels firm – what do you prefer?
- Does it all make sense - are the greenest vegetables also the firmest and have not lost chlorophyll to the cooking water?
- Discuss the results and find possible scientific explanations for what happens during heat treatment.
- Check cooking books for treatment of green vegetables, ask at home, ask chef's at restaurants. What do they recommend? Compare that information with your protocol.

Open ended investigations

You can start the investigation with broccoli, which gives the best result meaning good visible colour differences. Later the pupils can use other vegetables of their choice.

It is also possible to experiment with shortening of the cooking time in order to find a cooking time that gives no colour change but agreeable softening of fibres (i.e. texture change). This may be different for different types of vegetables.
It is possible to make the same investigation by comparing cooking at cooking plate with cooking in a micro wave oven and / or steam treatment (steam treatment only with water not buffer or salt) and / or roasting, stir frying etc.

Safety guidelines

It is important to use heat resistant beakers to avoid accidents. Using cooking plates instead of gas burners saves time since all 5 beakers can stand on the plate at the same time and is more safe.
Make sure that all groups have gloves to take the beakers off the cooking plate after 10 minutes. Some suppliers for laboratory equipment offer rubber gloves. This may be a good investment since they also prevent that the beakers slip and brake.

Preparation and timing

Buffer solutions can be bought at suppliers of chemicals. They are usually not harmful – but check the safety instruction on the labels.
The procedures take 1½ hours. It takes additional ½ hour to evaluate the vegetables for colour and texture and to discuss the findings.

Troubleshooting

Use only fresh vegetables. Frozen vegetables are often pretreated (blanched) and may not react. The same goes for canned food. Do not replace buffers with acid or alcaline water.

Suppliers

No special equipment is needed. Buffer solutions can be purchased by any supplier of laboratory chemicals. Choose non hazardous buffers.

Storage of materials

You can store the plates with vegetables in a refrigerator for 1-2 days in closed containers.

Other sources of information

For more literature, see

www.volvoxdk.dk

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From page 1: Which batch of peas do you prefer?

Think again !

While the brown peas are still firm after 10 minutes in acid water, the nicely green peas cooked in salt water are too soft and not very delicious to look at. The firmness of vegetables in acid cooking water may be due to denaturation of protein (like in boiled eggs) while alkaline pH is known to dissolve proteins in water. Furthermore the cell walls react differently to different pH.

Results from students at Solroed Gymnasium 2006

Treatment	Buffer pH 4	Buffer pH 7	Buffer pH 8	Tapwater	Saltwarter
pH before cooking	4	7	8	7	7
pH after cooking	4	7	8	8-9	8-9
colour of cooking water	clear	light green	dark green	dark green	dark green
colour of vegetable	brown	as the uncooked	very green	very green	very green
texture of vegetable	hard and firm	soft	very soft	soft	soft