



## Workshop: EDIBLE LIQUID FRACTAL:

**Goal:** prepare an edible fractal structure mixing two liquids. The fractal must grow at a rate that its growth could be seen by the human eye. Besides, the fractal will be sweet!

### Ingredients:

#### For the base liquid:

- + 0,5 L of water
- + 100 g of honey (do not use dark honey)
- + 2 units of star anise (to flavour the dessert)
- + 100 g of Xylitol
- + 1,5 g of Xanthan gum

#### For the coloured liquid

- + 15 mL of water
- + 2 g of sugar
- + Food colouring

#### Material (we can use either lab material or equivalent kitchen utensils instead)

- + 500 mL beaker
- + 500 mL graduated cylinder
- + Electronic scale
- + Spoon
- + Watch glass
- + Hand blender
- + Tripod
- + Wire gauze
- + Bunsen burner
- + Crystallization dish





### Preparation of the base:

- ✚ Pour water and honey into a 500 mL beaker
- ✚ Heat it until the mixture boils
- ✚ Once it is boiling, steep the star anise for 5 minutes
- ✚ Let it cool for 10 minutes
- ✚ Add the Xylitol and the Xanthan gum
- ✚ Mix with a blender. Do not leave any lumps of Xanthan Gum
- ✚ Keep the mixture for a day in the fridge (4-8 °C)

### Preparation of the coloured liquid

- ✚ Mix water, sugar and food colouring
- ✚ Heat the mixture (not to much, 40 °C in the microwave is enough).
- ✚ Use different colours

### Creation of the fractal:

- ✚ Pour gently a spoonful of the coloured solution onto the cool base.





**STEMcooking**  
Discovering Science and  
Maths through cooking  
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Link to the video: [https://youtu.be/w4vJ\\_Knw4j8](https://youtu.be/w4vJ_Knw4j8)





## Questions:

1. What is a fractal?
2. Where can we find fractals?
3. Can you name one example of fractal used in cooking?
4. Why do you think that most of examples of fractals are solids?
5. Do you know what a polymer is?
6. What is the key component of the recipe? Why?
7. Why do we have to heat the mixture that contains the Xanthan gum?
8. Why do we have to let it cool?
9. Can you find a natural phenomenon that looks like the fractal of the experiment?
10. Do you know how to make a fractal out of paper? It is easy. Look on the net and you will find lots of examples





## Answers:

### 1. What is a fractal?

A fractal is a geometrical or physical structure with an irregular or fragmented shape repeated at all scales of measurement. It means that we can see the same structure or pattern no matter the scale, no matter how close or how far we look at the object. This pattern is so irregular that it cannot be described using traditional geometric methods

### 2. Where can we find fractals?

We are surrounded by fractals.

Some of them are made by humans, creating beautiful artistic pictures. Others are created by nature, specially by plants: Rose, Cactus, Fern, Branches of a tree ... Other examples: Chorales, Human lungs, Snowflakes, a lightning...

### 3. Can you name one example of fractal used in cooking?

One beautiful example is the Romanesco Broccoli.

### 4. Why do you think that most of examples of fractals are solids?

Because they need a solid structure to support the components of the fractal and keep growing (very slowly) as most of them are living beings

### 5. Do you know what a polymer is?

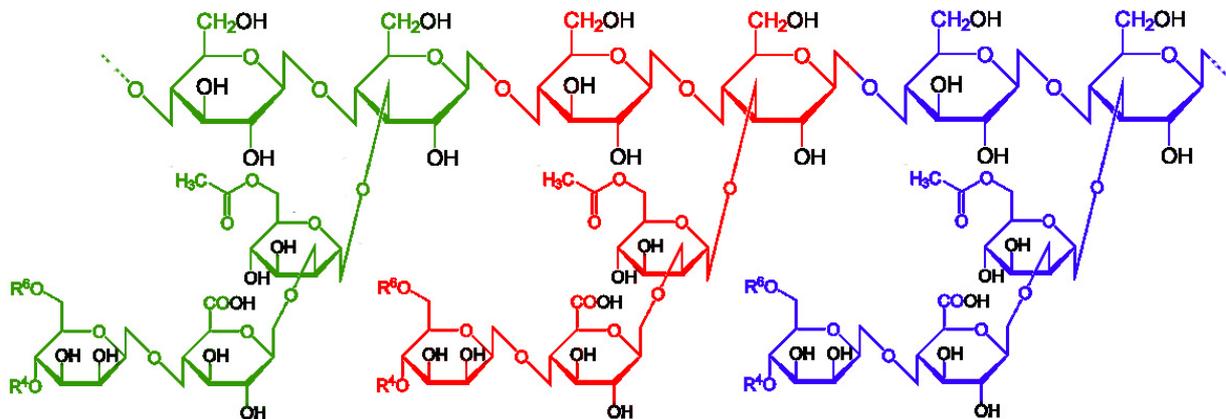
A polymer is a large molecule composed of many repeated subunits, called monomers. It resembles to the links of a chain.

### 6. What is the key component of the recipe? Why?

The key component is Xanthan Gum. It is a food additive known as E415, considered totally safe, and it is naturally produced by a bacteria. However, it can be synthesised by fermentation of different sugars.

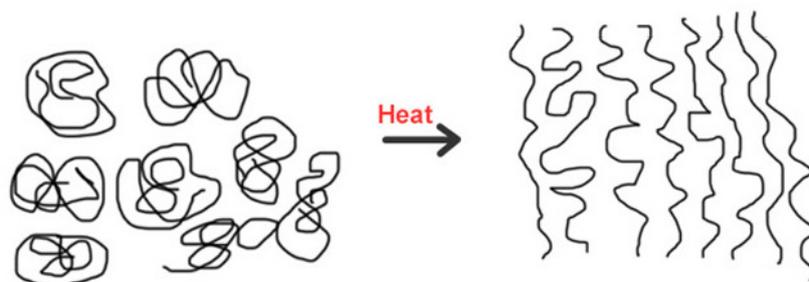


It is a powerful thickening agent. The reason of its behaviour is in its chemical structure: Xanthan gum is a polymer (polysaccharide). So, it is composed of a lot of units of sugars, forming very long chains. Chemically it is a polyalcohol, having a lot of hydroxide groups in its structure (in black) that can be bonded by H-bridges, a type of interaction between hydroxide groups in this case.



### 7. Why do we have to heat the mixture that contains the Xanthan gum?

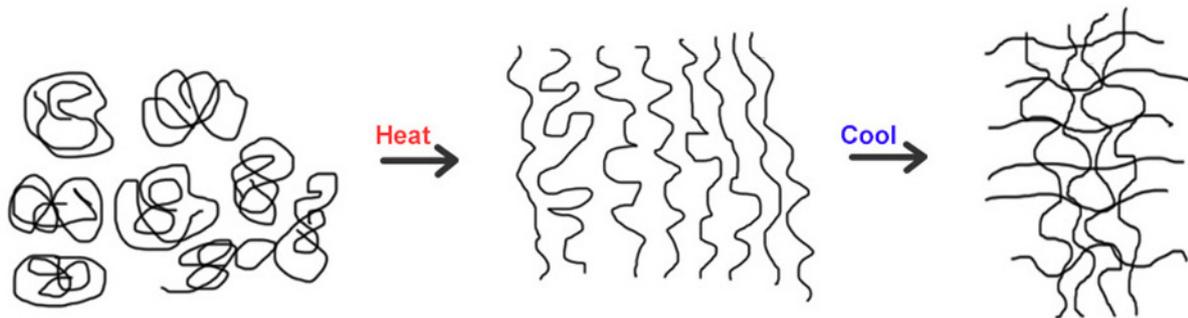
Because it is difficult to solve it in cold water as they create an emulsion. When it is cold, the long chains of polymer are entangled (see below) because there are lots of interactions by H-bridge in each molecule of polymer, that causes them to roll up. If we heat the mixture of water and Xanthan gum, the long chains of polymer untangled and the Xanthan gum dissolves better





## 8. Why do we have to let it cool?

If we let the Xanthan gum cool, now the polymers interact again, but this time the H-bridges will be created among different chains of polymer, forming some kind of molecular "framework" or "grid" that gives very interesting elastic properties to the liquid (see the picture).



In this way, it acts as a jelling agent, creating the necessary support for the other liquid to pass through the microscopic channels of the surface, advancing by capillarity and creating the image of the desired fractal.

## 9. Can you find a natural phenomenon that looks like the fractal of the experiment?

It works in the same way as a river flows. Look at these pictures:

<http://paulbourke.net/fractals/googleearth/>

As you can see, water flows through the different obstacles that it finds in its way to the sea. It uses the different natural channels that are on the ground and fill them with water.

So, the idea is the same, we need one liquid as base, in the same way as the bottom of the river, with enough elasticity (given by Xanthan gum) to hold another liquid that flows through the channels created on the first one. Using different colours, we should be able to see how these channels are filled with water creating the image of a fractal.

## 10. Try to make a fractal out of paper. It is easy.

For example:

<https://youtu.be/4YDHsMUQbVg>

