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Spherification

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Spherification, i.e., the formation of liquid spheres inside a thin gelled membrane, is described theoretically in the chapter of this handbook by Luck, and also by Berardi et al. Here, I give information about the main ingredients, as well as technical advice, before giving recipes using the technique for either the direct or the reverse method.

Some Technical Information

Sodium Alginate

Sodium alginate is a polysaccharide extracted from the ocean’s brown algae, first mentioned in 1881 by the British chemist E.C.C. Stanford. It has the properties of a hydrocolloid (see the chapter by Edwards-Stuart and Barbar) and is used in the food industry as a stabilizer and thickening agent due to its ability to retain water. When the alginate moiety reacts with calcium ions, it makes a non-thermoreversible gel, which is why it is used in the process of “spherification” (Adria, 2010; Caballero et al., 2003).

Instructions for Use

The minimum quantity to obtain the gelling of solidum alginate around liquid spheres is 10 g/kg (more than is used for making jams, jellies, and preserves). In basic spherification, small proportions of alginate (0.4% to 0.7%) are used in the product to include in the spheres, and a calcium salt (e.g., chloride) (0.5% to 1% concentration) bath is used. In reverse spherification, the calcium salt is added to the liquid phase to include in spheres, and the bath contains the alginate.

Stirring is used for dissolution, but heating is not necessary, and the alginate solution is left in a refrigerator overnight to hydrate. If it is strongly stirred, air bubbles are formed, which are lost when the solution is left to rest, while leaving it to hydrate slowly avoids air absorption. Heating in the presence of sugars aids the hydration process, and it is possible to remove air from the solution with a vacuum packing machine.

In practice, alginic acid can precipitate if pH < 3.65, so trisodium citrate can be used to adjust the pH to reach pH 5 (Table 128.1).

The Role of Calcium

Calcium ions are naturally present in a number of food ingredients, such as milk and milk-derived products, as well as plant and animal tissues (Table 128.2).

For spherification, various calcium salts can be used: chloride, gluconate, glucose lactate, and lactate. They are often extracted from dairy and mineral products. Calcium chloride is bitter, and so spheres should be washed before use. Bear in mind that calcium ions can be “trapped” by sequestrants with sodium gluconate, sodium tripolyphosphate and calcium disodium ethylene diamine tetra-acetate, and other phosphates. Calcium chloride and calcium sulfate tend to absorb water from the air, but the quantities given here are for the water-free (anhydrous) forms. Different calcium salts contain different amounts of calcium ions per mass unit, and this is the basis on which the calcium bath is prepared. The most common calcium salts used in spherification and the concentrations to create the calcium bath are given in Table 128.3.

To have the same concentration of calcium ions in the solution, different calcium salts must be used in different quantities, based on the molecular weight (MW). Table 128.4 shows the amounts of various salts to add, as well as concentrations obtained when adding the salts at 0.5%, 2.5%, and 5% levels; e.g., to obtain the same calcium concentration that you get with a 0.5% solution of calcium chloride, you must prepare either a 1.94% solution of calcium gluconate or a 0.98% solution of calcium lactate.

<table>
<thead>
<tr>
<th>Initial pH</th>
<th>Trisodium citrate to adjust (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>2.5</td>
<td>0.85</td>
</tr>
<tr>
<td>3</td>
<td>0.27</td>
</tr>
<tr>
<td>3.5</td>
<td>0.082</td>
</tr>
</tbody>
</table>

Source: Lersch, 2014.
In order to make successful spheres, the following directions should be observed:

1. Prepare liquid for basic spherification like most hydrocolloids. Disperse the sodium alginate in the liquid (juice, puree, etc.) with a hand immersion blender. Sodium alginate is very “sticky”; thus, for thicker liquids like purees, it may be necessary to first add some water to the liquid in which to dissolve the sodium alginate.

2. The liquid needs to be cold, and if it is too acidic, sodium alginate will not hydrate and will make a thick solution.

3. Above all, check the pH of the liquid and adjust it to 4.5. For pH correction, you can use trisodium citrate, in quantities that you control using a pH meter or pH papers.

4. The liquid should not contain calcium ions; otherwise, the gelation will occur in the bath before you make spheres. Also, sodium alginate will not hydrate properly in brandies, and it is very important that you first disperse alginate in water, juice, purée, etc. in order to allow alginate to hydrate, before adding to alcohol; otherwise, liquid will leak out and break in the process of cooking, and you will not have the right effect of spherification.

For the solution to be included in spheres:

a. Add sodium alginate into 30% of the prepared liquid for making spheres.

b. Disperse with hand immersion blender; after several minutes for incorporating alginate into the liquid, a very sticky solution will be produced.

c. Then add the rest of the prepared liquid for spherification; disperse with the hand immersion blender and hydrate in the fridge for 2 h.

d. This rest is important for avoiding air bubbles, so that the spheres will be able to sink and “cook” properly. As mentioned earlier, one can also use a vacuum packing machine for faster hydration in some recipes.

e. Prepare the calcium bath with distilled water to achieve the right thickness. Tap water containing too much calcium cannot be used.
For the calcium bath:

- Prepare the calcium bath by adding calcium salt to the distilled water; e.g., use 0.5% to 1% calcium chloride to water.
- Dissolve in water with stirring. It will dissolve very quickly, or a magnetic stirrer may be used.
- Adding a small amount of sugar to your calcium salt bath will stop spheres from sticking to the bottom of the container in the process of spherification. The calcium solution can be stored in the refrigerator for several days before using.

**Process of spherification in calcium bath:**

- Take your liquid with the content of sodium alginate from the fridge.
- Also take calcium chloride bath, syringe, spherification spoon, paper towels, and timer.
- Prepare one more bowl with water for washing and rising spheres. This step will remove all calcium content from the surface of the spheres.
- Using a measuring spoon for best results, take the liquid juice or puree with sodium alginate added.
- Gently pour liquid from spoon into the sodium chloride bath. Transfer all liquid from spoon into bath, and start to move the spheres around with spoon in a circular motion without touching the spheres.
- This will allow to cook your spheres and to start the formation of a gel from the top to the bottom.
- Stir gently for 2 min in a calcium chloride bath.
- Collect the sphere with a spherification spoon from a calcium bath and transfer to a bowl with water.
- Start stirring the water around the spheres with a spoon to wash the calcium from the spheres. Be careful when moving the spheres with a spoon from a calcium bath or the membrane will break easily, because it is thick outside and liquid inside.
- Dry with paper towel under a spherification spoon to remove any remains of water or gel around the spheres.

In the process of basic spherification, you must serve your basic spheres immediately, because the process of gelling is still going on. Adding xanthan gum to the liquid can increase liquid viscosity; when the liquid is thick, it separates in the bath at the gelling point (Table 128.5).

### Recipes

**Basic Spherification Recipe**

**Ingredients for a calcium bath:**

- 100% deionized water
- 0.5% calcium chloride

Set a glass beaker on the magnetic stirrer, add water to the glass beaker, and start stirring on medium speed, slowly adding calcium chloride. Stir for 3 min and transfer solution into the container to the fridge before usage.

**Ingredients for a sphere (for a base of diced tomatoes):**

- 0.5% sodium alginate
- 0.20% xanthan gum
- malic acid to taste
- fructose to taste
- 1.4% salt
- 0.20% “Onium” odorant solution (*Iqemusu*)
- 0.10% red colorant, hydrosoluble

### TABLE 128.5

**Quantities for the Various Spherification Methods**

<table>
<thead>
<tr>
<th>Components of the setting bath</th>
<th>Added to the sphere base</th>
<th>Possibilities of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium chloride 0.5–1%</td>
<td>Sodium alginate 1%</td>
<td>Possibility of adding xanthan gum 0.2–0.5% (xanthan gum thickens liquids) Use trisodium citrate when the liquid is too acidic or high in calcium</td>
</tr>
<tr>
<td>or calcium gluconate 2.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse</td>
<td>Calcium lactate 3%</td>
<td>Possibility of adding xanthan gum 0.2–0.5%</td>
</tr>
<tr>
<td>Sodium alginate 0.5%</td>
<td>Iota carrageenan 2%</td>
<td>Hydrate carrageenan for at least 5 h; can also make reverse spherification.</td>
</tr>
<tr>
<td>Tartaric acid 0.2%</td>
<td>Calcium lactate 5%</td>
<td>Can also make direct spherification.</td>
</tr>
<tr>
<td>Carrageenans (direct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium phosphate 5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low methylated (LM) pectin (reverse)</td>
<td>Calcium lactate 5%</td>
<td></td>
</tr>
<tr>
<td>Pectin 2%</td>
<td>Low acyl gellan 0.2%</td>
<td>Sodium hexametaphosphate 0.1% Best made with low-acid moderate-calcium liquids; make frozen spheres and set in calcium bath; can also make reverse.</td>
</tr>
<tr>
<td>Gellan (direct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium gluconate 6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note:* For the various cases, xanthan gum can be added, as it thickens liquids, and trisodium citrate is helpful when the liquid is too acidic or high in calcium (Myhrvold *et al.*, 2011).
Method:

1. Cut tomatoes, and transfer them into the food processor; blend for 3 min.
2. Take four centrifuge bottles; put one bottle on scale and transfer the tomato puree into bottle to weight of 150 g; do the same with the three other bottles.
3. Transfer the bottles into the centrifuge, and set at 4000 rpm for 12 min.
4. Prepare a clean measuring glass cup, spoon, and filtration paper.
5. Store bottles from the centrifuge so that the tomato juice and the pulp separate.
6. Prepare the glass beaker on a working surface and set filtration paper over the filter, then open bottles and with the spoon hold the pulp from the tomatoes in the bottle, at the same time carefully passing the rest of the liquid through the filtration paper into the glass beaker.
7. When you have a clear tomato juice, you are ready to make red tomato juice. Prepare a pH indicator (pH paper or pH meter), magnetic stirrer, refractometer, pipette, spoon, and paper towels.
8. In the glass beaker with magnetic stirrer on, add salt to taste and adjust the sweetness of the juice by adding fructose while stirring constantly; take some juice with the pipette between additions of fructose, and check the content of fructose in your juice (IN Brix) with the refractometer. Repeat this procedure a few times until you get 20 °Brix.
9. Adjust the acidity of the juice by adding some Citras (Texturas Inc.) while stirring constantly. You have to reach a pH of 4.6.
10. Disperse the red water-soluble colorant and the odorant solution in the juice with the hand immersion blender.
11. Disperse sodium alginate in 30% of tomato juice with the hand immersion blender; then add this solution to the rest of the juice and disperse for 2 min more.
12. Pass through a fine mesh sieve.
13. Remove air from solution with vacuum packing machine or allow the solution to hydrate for 1 h.
14. Set up the calcium bath and use the measuring spoon to pour some juice solution into the calcium bath; wait for about 3 min, moving the spheres around in the bath solution with the spherification spoon.
15. Take the spheres out of the bath, gently rinse in water and serve.

Adding xanthan gum to the liquid can increase liquid viscosity. When the liquid is thick, it separates in the bath at the gelling point.

Reverse Frozen Spherification

Ingredients for the sodium alginate bath:

- 100% distilled water
- 0.5% sodium alginate

Method for the bath:

1. Set cold deionized water in a jug and add sodium alginate; disperse it with a hand immersion blender for 2 min.
2. Pass the liquid through a fine mesh sieve to prevent clumps and create a smooth-textured liquid.
3. Seal the mixture into a vacuum packing bag and refrigerate to hydrate for 2 h.
4. After this rest, transfer the liquid to a food storage container and use it like a bath.

Ingredients for the spheres:

- 70% Greek yoghurt
- 20% kefir yoghurt
- 10% Mediterranean yoghurt powder (Sosa)
- 0.20% calcium salt
- salt to taste
- 0.22% xanthan gum
- solution of 0.1% lactic acid
- 200 mL olive oil

Method:

In this recipe, a lower proportion of calcium is used, because dairy products like cheese, milk, and yoghurt are already rich in calcium.

1. Put the Greek and kefir yoghurt in a glass beaker.
2. Add all substances to the yoghurt except the lactic acid and the odorant solutions.
3. Disperse with a hand immersion blender for 2 min.
4. Pass the solution through a fine mesh sieve to get a smooth solution.
5. Adjust yoghurt solution with odorant solutions, and adjust the acidity with lactic acid, adding the solution of lactic acid drop by drop. Each time you add a drop, stir the solution with a spoon.
6. Pass the yoghurt solution one more time through a fine mesh sieve into a squeeze bottle and hydrate for 1 h in the refrigerator.
7. Prepare a bowl with clean water, paper towels, spherification spoon, and double fruit baller spoon, and prepare olive oil in a small container.
8. Transfer the container with the sodium alginate bath from the refrigerator to the working space. Prepare squeeze bottle with the yoghurt solution.
9. Take the baller spoon in one hand and set the bottom of the spoon into the alginate bath, and with the other hand, start pushing yoghurt solution from the squeeze bottle to the top of the baller spoon, while at the same time moving the spoon towards the bottom of the alginate bath. When you reach the bottom of the bath, turn the spoon around and move from the alginate bath, making slow, circular movements around the spheres for about 3 min.
10. Remove the spheres from the bath with the spherification spoon and rinse them in water for 10 seconds.
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11. Transfer the spheres to the container with olive oil to preserve spheres for up to several days in the refrigerator before usage.

In a modification of the process of reverse spherification, frozen reverse spherification is possible. Chefs use this technique when alcohol is in the spherification recipes. In this case, the solution with sodium alginate is added into hemispheric moulds and frozen in a deep freezer before usage.

Cryogenic Cooking – Cryo-Diffusion for Making Frozen Spheres Which Are Then Gelled in a Sodium Alginate Bath

Cryogenic cooking, also called cryo-cooking, has become more popular with the molecular cuisine movement (see the chapter by Barham in this book). Chefs have been working with frozen carbon dioxide or liquid nitrogen for a number of years in high-end restaurants.

One can control frozen textures, foams, pearls, etc. without any water crystals or air inside the solution. Liquid nitrogen is a very good way to preserve the flavour, consistency, colour, and nutritional value of foods, especially for delicate products. The most interesting part is that, in the process, you can remove the air from the solution used.

When using liquid nitrogen, safety rules are extremely important, because liquid nitrogen has an extremely low temperature, and if it comes into contact with the skin, hands, or tissue for more than a couple of seconds, it can cause serious injury. Individuals should always wear eye protection and use cryo-gloves when handling this material. Store the dewar containing liquid nitrogen with extreme care.

The general process:

1. Combine gelling substances in appropriate proportions. Ensure that the pH is not too low, and add trisodium citrate until the pH is above 4.5.
2. Prepare the alginate bath; disperse water and sodium alginate with a hand immersion blender.
3. Remove air from the solution with a vacuum packing machine or leave to hydrate for 1 h in the refrigerator.
4. Disperse the various ingredients of the liquid you will cryo-cook (puree, juice, etc) using the hand dispersion blender.
5. If needed, pass this liquid through a fine mesh sieve.
6. Transfer the liquid containing calcium (juice, puree, etc.) into a squeeze bottle or syringe.
7. Take out the alginate bath from the refrigerator and bring it to your working surface; prepare an additional metal bowl.
8. Put on gloves and safety glasses before you start to transfer liquid nitrogen from the dewar to the cryo-bowl. Handle liquid nitrogen with extreme care.
9. Start to drop small droplets of the prepared liquid solution from the squeeze bottle or syringe into the cryo-bath, stirring the cryo-bath with a whisk, and at the same time, with the other hand, start to drop liquid in the cryo-bath and wait for 2 min.
10. Collect the shaped frozen spheres with a large spherification spoon from the cryo-bath.
11. Transfer the frozen spheres to a metal bowl and set to −40 °C in a fast cold freezer.
12. Take some frozen spheres from the metal bowl with a big spherification spoon, drop into an alginate bath, and allow to react for 2 min.
12. Collect the cryo-spheres with a spherification spoon from the alginate bath after 2 min, rinse in water, and serve.

A Recipe with Cranberries

Preparation of the alginate bath:

1. Prepare a sodium alginate bath with 100% deionized water and 0.5% sodium alginate; disperse using a hand immersion blender for 2 min.
2. Pass this liquid through a fine mesh sieve to create a smooth texture.
3. Vacuum and seal this mixture to avoid air bubbles, or hydrate for 2 h in a refrigerator.
4. Transfer the solution to a food storage container.

Ingredients for the cranberry purée:

- 100% fresh cranberries
- malic acid to taste
- fructose to taste
- 0.5% calcium chloride
- 0.30% low acyl gellan
- 0.25% “Frum” odorant solution (Iqemusu)
- 0.25% “Balqin” odorant solution (Iqemusu)
- 0.20% xanthan gum

Method:

1. Wash the cranberries and make a puree in a jug with a hand immersion blender (mixing for 3 min).
2. Pass the puree twice through a fine mesh sieve until the consistency of the puree is almost silky.
3. Disperse calcium chloride, xanthan gum, and low acyl gellan into the puree.
4. Pass through a fine mesh sieve.
5. Adjust the pH of the cranberry puree with malic acid, adding small amounts at a time and measuring the pH with a pH indicator until the pH is equal to 3.9.
6. Add fructose to the puree while stirring; after each addition, transfer a drop of the puree over the surface glass of the refractometer and measure the sugar content until you get 25 °Brix.
7. Add the odorant solutions to the puree.
8. Remove air from solution with a vacuum sealer.
9. Transfer the cranberry puree into a squeeze bottle and set in the refrigerator before usage.
REFERENCES


MolecularRecipes. 2020. www.molecularrecipes.com/spherification: