World Journal of Pharmaceutical Sciences
ISSN (Print): 2321-3310; ISSN (Online): 2321-3086
Published by Atom and Cell Publishers
Available online at: http://www.wjpsonline.org/
Editorial

Cross linking of calcium ion in alginate produce spherification in molecular gastronomy by pseudoplastic flow

Dr. Dhrubo Jyoti Sen

D. Pharm., B.Sc. (Hons), B.Pharm. (Hons), M.Pharm., Ph.D., FICS, CChem FIC (India), CChem FRSC (UK), CSci (UK), AOM (USA)
Professor, Department of Pharmaceutical Chemistry, Shri Sarvajanik Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana-384001, Gujarat, India
Phone: 00-91-2762-247711 (Ext-307); Fax: 00-91-2762-247712
Website: http://sspcmsn.org/yahoo_site_admin/assets/Facultyprofiles/drdjsen.pdf
Mobile: 09979132823, E-mail: dhrubosen69@yahoo.com

Recipient of K.K. Acharjee Award, Recipient of Jewel of India Award, Recipient of Rashtriya Vidya Saraswati Puraskar, Recipient of Rashtriya Vidya Jyoti Award and Gold Medal, Recipient of Life Time Achievement Gold Medal Award, Recipient of Eminent Educationist Award, Recipient of International Gold Star Award, Recipient of Vidya Ratan Award, Recipient of Gyan Jyoti Gold Medal Award, Recipient of Bharat Excellence Award & Gold Medal, Recipient of India Inspiration Award & Gold Medal, Recipient of Seva Chakra Puraskar, Recipient of American Order of Merit, Recipient of Golden Educationist of India Award, Recipient of NEHS Global Award of Excellence and Gold Medal of Excellence, Recipient of NEHS Jewel of India Award and NEHS Gold Medal of Excellence, Recipient of Academician of the Year Award, Recipient of Outstanding Faculty of the Year Award, Recipient of Award for Special Achievement in Technology, Recipient of Distinguished Faculty Award in Medicinal Chemistry

ABSTRACT

Spherification is a modern cuisine technique that involves creating semi-solid spheres with thin membranes out of liquids. As a result of this, a burst-in-the-mouth effect is achieved with the liquid. Both flavor and texture is enhanced with this culinary technique. Spheres can be made in various sizes as well as various firmness. This makes it possible to encase liquids within the solid spheres. Calcium chloride and sodium alginate are the two basic components used for this technique. Sodium alginate is taken from seaweed, while calcium chloride is a type of salt used in cheese making. The sodium alginate is used to gel the chosen liquid by dissolving it directly into the fluid. This will cause the liquid to become sticky, and proper dissolving must be done by mixing. The liquid is then left to set to eliminate any bubbles. Once ready, a bath is prepared with calcium chloride and water. The liquid is then dropped into the bath using a spoon or syringe depending on the desired sphere size. Once set, the spheres are then removed and rinsed with water to remove any excess calcium chloride. This process causes the gel to form a membrane when it comes into contact with the calcium chloride, encasing the liquid. The spherification process consists of two versions - direct and reverse. In direct spherification, gelling solutions like sodium alginate is mixed directly with the chosen liquid and dropped in calcium chloride and water to form a thin gel shell. In this version, the spheres are easily breakable and should be consumed immediately. In reverse spherification, alcohol and milk are fitting liquids. It uses calcium lactate, as it is found in dairy products, added with calcium chloride and dumped in a sodium alginate bath to form the covering around the liquid food. Unlike the direct version, the gelling stops and does not continue into the liquid orb. This result in having thicker shells so they do not have to be consumed immediately.
Keywords: Spherification, Molecular gastronomy, Cross linking, Calcium chloride, Calcium lactate gluconate, Sodium alginate, Xanthan Gum, Basic or Direct Spherification, Reverse Spherification, Frozen Reverse Spherification, Popping boba, Caviar, Spherical Mango Ravioli, Liquid Pea Ravioli, Caviar of Cointreau, Yoghurt Spheres, Liquid Mozzarella Spheres, Spherical Olives, Gellification

INTRODUCTION

Molecular gastronomy is a sub-discipline of food science that seeks to investigate the physical and chemical transformations of ingredients that occur in cooking. Its program includes three axes, as cooking was recognized to have three components, which are social, artistic and technical. Molecular cuisine is a modern style of cooking and takes advantage of many technical innovations from the scientific disciplines. The term "molecular gastronomy" was coined in 1988 by late Oxford physicist Nicholas Kurti and the French INRA chemist Hervé This. Some chefs associated with the term choose to reject its use preferring other terms such as multisensory cooking, modernist cuisine, culinary physics and experimental cuisine. **Spherification** is the culinary process of shaping a liquid into spheres usually using sodium alginate and either calcium chloride or calcium lactate gluconate, which visually and texturally resemble roe. Roe or hard roe is the fully ripe internal egg masses in the ovaries, or the released external egg masses of fish and certain marine animals, such as shrimp, scallop and sea urchins. As a seafood, roe is used both as a cooked ingredient in many dishes and as a raw ingredient. The roe of marine animals, such as the roe of lump sucker, hake and salmon, is an excellent source of omega-3 fatty acids. Roe from a sturgeon or sometimes other fishes is the raw base product from which caviar is made. Caviar is a delicacy consisting of salt-cured fish-eggs of the Acipenseridae family. The roe can be "fresh" (non-pasteurized) or pasteurized, with pasteurization reducing its culinary and economic value. Traditionally, the term caviar refers only to roe from wild sturgeon in the Caspian and Black Sea (Beluga, Ossetra and Sevruga caviars). Depending on the country, caviar may also be used to describe the roe of other fish such as salmon, steelhead, trout, lumpfish, whitefish, carp and other species of sturgeon. Caviar is considered a delicacy and is eaten as a garnish or a spread.[1]

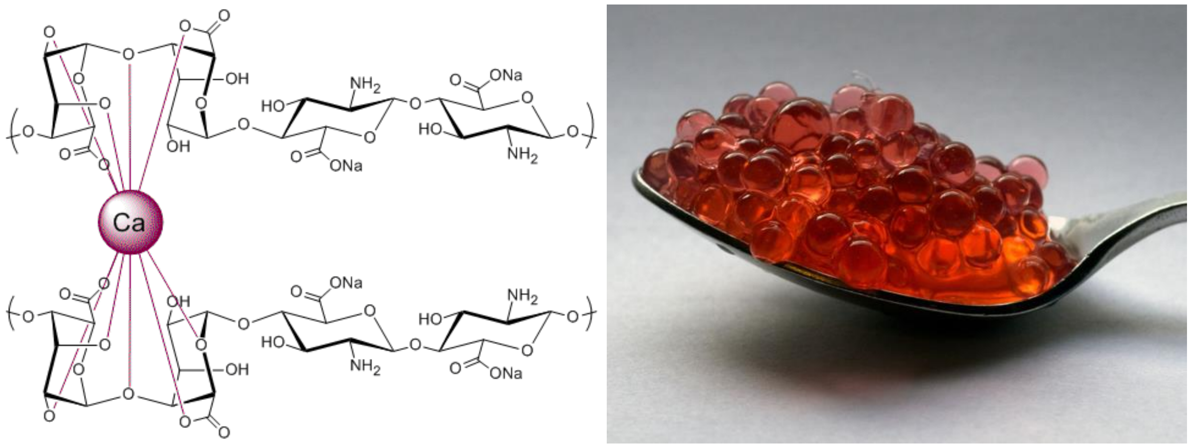

Figure-1: Cross linking of calcium with alginate producing spherification

The term soft roe or white roe denotes fish milt. The technique was originally discovered by Unilever in the 1950s (Potter 2010, p. 305) and brought to the modernist cuisine by the creative team at el Bulli under the direction of executive chef Ferran Adrià. Ferran Adrià Acosta (born Fernando Adrià Acosta) is a Spanish chef born on May 14, 1962 in L'Hospitalet de Llobregat (Barcelona, Catalonia Spain). He was the head chef of the el Bulli restaurant in Roses on the Costa Brava and is considered one of the best chefs in the world.

Classification of spherification:

Spherification Overview: The spherification technique was introduced by el Bulli in 2003. It consists of a controlled jellification of a liquid which forms spheres when submerged in a bath. The spheres can be made of different sizes and have been given names like caviar when they are small, eggs, gnocchi and ravioli when they have larger size. The resulting spheres have a thin membrane and are filled with the flavored liquid. A slight pressure of the mouth on the sphere makes it burst and release an amazing explosion of flavor. The spheres are flexible and can be carefully manipulated. It is possible to introduce solid elements in the sphere which will remain in suspension in the liquid giving the possibility of introducing multiple flavors and textures in one preparation. It sounds complicated but the spherification technique can be easily mastered at home with one of Molecular Gastronomy kits. The Molecular Gastronomy Essentials Kit has all the ingredients and tools necessary to make any type of sphere. There are two main kinds of spherification techniques and each of them has its advantages and disadvantages which make them more suitable for certain recipes. The Basic Spherification technique consists of submerging a liquid with sodium alginate in a bath of calcium. The Reverse Spherification technique consists of submerging a liquid with calcium content in a bath of sodium alginate. When the liquid drops into the bath, a thin coat of gel forms around the droplet as the calcium reacts with the sodium alginate.

There are also a couple of other techniques to create spheres which consist of instant jelling by immersing the liquid in cold oil or liquid nitrogen, but these are made with a completely different process and the resulting spheres are solid and have no liquid inside. So these are usually not considered "spherification" techniques. There are two main methods for creating such spheres, which differ based on the calcium content of the liquid product to be spherified. For flavored liquids (such as fruit juices) containing no calcium, the liquid is thoroughly mixed with a small quantity of powdered sodium alginate, then dripped into a bowl filled with a cold solution of calcium chloride, or other soluble calcium salt. Just as a teaspoonful of water dropped into a bowl of vegetable oil forms a little bubble of water in the oil, each drop of the alginated liquid tends to form into a small sphere in the calcium solution. Then, during a reaction time of a few seconds to a few minutes, the calcium solution causes the outer layer of each alginated liquid sphere to form a thin, flexible skin. The resulting "popping boba" or artificial "caviar" balls are rinsed then in water and saved for later use in food or beverages. Popping boba is a type of boba used in bubble tea. Unlike traditional boba, which is tapioca-based, popping boba is made using the spherification process that relies on the reaction of sodium alginate and either calcium chloride or calcium lactate. Popping boba has a thin, gel-like skin with juice inside that bursts when squeezed. The ingredients for popping boba generally consist of water, sugar, fruit juice or other flavors and the ingredients required for spherification. Popping boba is a complementary good to bubble tea and frozen yogurt. It can serve as a topping for frozen yogurt and a substitute for traditional boba in bubble tea.[2]

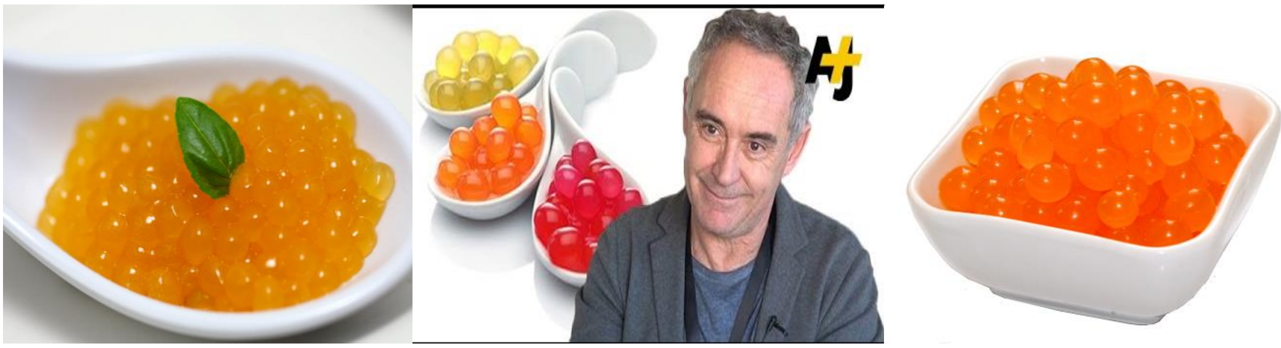

Figure-2: Ferran Adrià the founder of popping boba

Basic Spherification: The Basic Spherification technique is ideal for obtaining spheres with a very, very thin membrane that is almost imperceptible in your mouth. It results in a sphere that easily explodes in your mouth as if there is no solid substance between your palate and the liquid. The main problem of this technique is that once the sphere is removed from the calcium bath, the process of jellification continues even after rinsing the sphere with water. This means that the spheres need to be served immediately or they would convert into a compact gel ball with no magical liquid inside. The other issue of this technique is that jellification does not occur if the liquid acidity is high ($pH<3.6$) but this can be corrected by adding sodium citrate to the liquid to reduce the acidity level before the spherification process.

The Basic Spherification technique doesn't work with ingredients that have high calcium content Examples of Basic Spherification are "Spherical Mango Ravioli", "Liquid Pea Ravioli", "Caviar of Cointreau".

Figure-3: Spherical Mango Ravioli , Liquid Pea Ravioli and Caviar of Cointreau

Reverse Spherification

The technique of Reverse Spherification is much more versatile than Basic Spherification as it can make spheres with almost any product. It is best for liquids with high calcium content or alcohol content. Contrary to the spheres made with the Basic Spherification process, these spheres have a thicker membrane and are long-lasting as the process of jellification can be stopped when the sphere is removed from the sodium alginate bath and rinsed with water. Thanks to these characteristics, the Reverse Spherification spheres can be manipulated more easily and can be used in more ways (for example as fillings in sponge cakes or mousses, in cocktails or can even be macerated in aromatized olive oil for a few days). Examples of Reverse Spherification are Yoghurt Spheres, Liquid Mozzarella Spheres and Spherical Olives. Reverse spherification, for use with substances which contain calcium or have high acid/alcohol content, requires dripping the substance (containing calcium lactate or calcium lactate gluconate or into an alginate bath. A more recent technique is frozen reverse spherification, which involves pre-freezing spheres containing calcium lactate gluconate and then submerging them in a sodium alginate bath. All three methods give the same result: a sphere of liquid held by a thin gel membrane, texturally similar to roe.

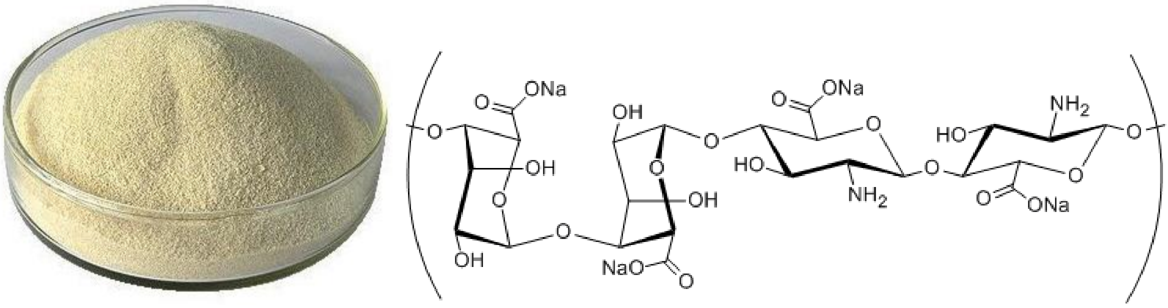

Figure-4: Sodium alginate

The Science of Spherification: Sodium Alginate is a natural polysaccharide product extracted from brown seaweed that grows in cold water regions. In presence of calcium, sodium alginate forms a gel without the need of heat. In Basic Spherification, the gelling occurs thanks to the diffusion method in which the cross linking calcium ion diffuses from an outer reservoir into an alginate solution. Gels form when a calcium salt is added to a solution of sodium alginate in water. The gel forms by chemical reaction, the calcium displaces the sodium from the alginate, holds the long alginate molecules together and a gel is the result. No heat is required and the gels do not melt when heated. The gel coating is formed inside the droplet. Because the calcium ions continue diffusing towards the center of the droplet even after removing the sphere from the calcium bath, the gellification process continues and will eventually form a solid gel sphere. In Reverse Spherification, the calcium ions diffuse from the droplet into the alginate bath, forming a gel coat outside the droplet of flavored liquid. Because the calcium ions are diffusing from the inside out and no alginate molecules are getting into the droplet, the gellification process stops as soon as the spheres are removed from the alginate bath.[3]

Figure-5: Yoghurt Spheres, Liquid Mozzarella Spheres and Spherical Olives

El Bulli – Spherification History

The Spherification technique was introduced at el Bulli by Ferran Adrià in 2003 marking an inflexion point in molecular gastronomy. As many other molecular gastronomy techniques, spherification was discovered by working together with a leading company in the food industry and of course, the genius of a chef like Ferran Adrià and the rest of el Bulli team. In 2003, Ferran Adrià and el Bulli team were visiting a company called Griffith España to see their installations when they came across a Mexican sauce that contained little balls in suspension which added acidity and spice when eaten.

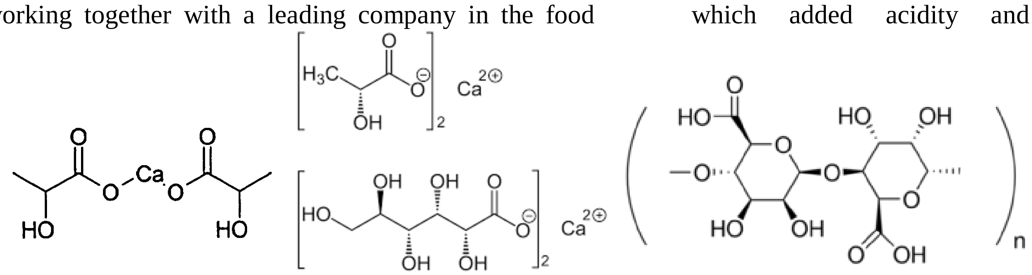

Figure-6: Calcium lactate gluconate

This reminded him of a drink he knew that contained little spheres made by immersing a liquid with sodium alginate in a bath of calcium. In both cases, the spheres were solid and did not have a liquid filling. They got a sample of the alginate and when they returned to el Bulli Taller, the experimentation began. Their first spherification experiment was with water as the main ingredient and a syringe to form little drops of the alginate solution. Because they used water in a water bath they couldn't see any spheres but when they strained the liquid they discovered that they had been able to create small balls with liquid inside (now called caviar). Right after that they tried with a spoon instead of a syringe to create a larger sphere and now the first "spherical ravioli" was created.

Basic or Direct Spherification

The Basic Spherification technique, also called Direct Spherification, consists of submerging a liquid with sodium alginate in a bath of calcium to form a sphere.

Pros of Basic Spherification: This technique is ideal for obtaining spheres with a very, very thin membrane that is almost imperceptible in your mouth and easily "explodes" as if there is no solid substance between your palate and the liquid. The gel membrane is formed inside the sphere using the flavored ingredient so there is no flavorless gel surrounding the sphere like in Reverse Spherification. This results in a better eating experience. It is easier to get a perfect sphere on the plate with Basic Spherification than with Reverse Spherification. Even if the resulting product is not a perfect sphere it will most likely look as one once you plate it as the subtle and flexible membrane will adapt and reshape when the quasi-sphere is placed on the plate. This is the preferred spherification method for producing "caviar" (small spheres) since the viscosity of the bath is thin allowing the small droplets to cohere into a spherical shape in the bath and the spheres don't stick together as in reverse spherification. There is no need to let the calcium bath rest for 12-24 hours before using it to obtain optimal results. This allows you to start and finish the preparation within an hour. In Reverse Spherification the sodium alginate bath needs to rest in the fridge for several hours to eliminate the air bubbles created by the process of dissolving the sodium alginate with the immersion blender.

Cons of Basic Spherification: Needs to be served immediately and cannot be stored. Once the sphere is removed from the sodium alginate bath, the process of jellification continues even after rinsing the sphere with water and it will convert into a compact gel ball with no magical liquid inside. Jellification does not occur if the liquid acidity is high (pH<3.6) but this can be corrected by adding an alkaline ingredient such as sodium citrate to the liquid to reduce the acidity level before the spherification process. Basic Spherification cannot be used with ingredients that have calcium content as it will react with the sodium alginate and gel before you pour the flavored ingredient in the calcium bath. If calcium content not too high it can be fixed. The consistency of the liquid inside the sphere is made a little gummy by the addition of sodium alginate. The good thing is that sodium alginate has no discernable flavor so it just increases the viscosity. You may need to rest in the fridge for several hours the flavorful liquid to eliminate the air bubbles created by the process of dissolving the sodium alginate with the immersion blender. Below are some tips to speed up the process. The delicacy of the resulting subtle membrane with the Basic Spherification process reduces the versatility of the resulting product. Any slight pressure will break them so they need to be manipulated carefully and they cannot be used as fillings in mousses or sponge cakes for example.

Preparing the Flavored Liquid for Basic Spherification: Dispersing and Hydrating Sodium Alginate: To produce Basic Spherification, you need a **solution with 0.5% sodium alginate** (0.5 g per 100 g of flavored liquid). Sodium Alginate, like most hydrocolloids, needs to be dispersed in the liquid and hydrated before it can gel in presence of calcium ions. This can simply be done by mixing the sodium alginate with an immersion blender or regular blender but you need to know a few things first to be successful. Liquid needs to be cold or otherwise the sodium alginate may hydrate and gel before it can get dispersed, resulting in gel lumps. To facilitate dispersion you can pre-mix dry sodium alginate with another powder ingredient such as sugar. Acidity of liquid cannot be high or the sodium alginate will transform into alginic acid which prevents hydration and thickens the liquid. pH of liquid needs to be above 3.6. Adjust the pH if necessary before adding sodium alginate. Liquid cannot contain free calcium ions as it will gel as they react with the sodium alginate before you can make the spheres in the calcium bath. Use a sequestrant to bind the free calcium ions so they are not available to react with the sodium alginate. Sodium alginate cannot hydrate well in alcohol, so disperse and hydrate in water or flavored liquid with high water content first.[4]

Liquids with Watery Density (e.g. melon cantaloupe juice): Add the amount of sodium alginate indicated in the recipe to 1/3 of the main ingredient and blend with an immersion blender until the sodium alginate is dispersed. Keep in mind that the sodium alginate will become sticky when it comes in contact with the liquid and it may take several minutes until it is completely dispersed and hydrated. Then add the remaining main ingredient liquid and let it rest in the fridge for 1 hour to eliminate the air bubbles created by the immersion blender. This last step is not only for aesthetics but will also make the droplet less buoyant in the bath and allow it to sink and be completely covered by the calcium bath.

Thick Liquids (e.g. mango puree): In this preparation, distilled water with no calcium content is added to the main ingredient to obtain the right consistency for spherification. Do not use tap water since it usually contains calcium. Add the amount of sodium alginate indicated in the recipe to the water used to correct the main ingredient density and blend with an immersion blender until the sodium alginate is dispersed like explained in the previous process. Then add the main ingredient and let it rest in the fridge for 1 hour to eliminate the air bubbles created by the immersion blender.

Calcium Salt	Calcium Content	Qty to Make 0.18% Ca solution
Calcium Chloride	36.1%	0.5%
Calcium Lactate	18.4%	1%
Calcium Lactate Gluconate	9.3%	2%

Table-1: Calcium ion contents in spherification

Correcting Acidity for Basic Spherification: The Basic Spherification process does not work if the main ingredient is too acidic (pH<3.6) as we mentioned before. If necessary, the acidity can be reduced by adding an alkali such as sodium citrate to the main ingredient (if watery liquid) or the water used to reduce the main ingredient density (if thick liquid) always before you add the sodium alginate. However, sodium citrate has a sour taste as well as a salty taste so adding too much of it will change the flavor of the liquid in the sphere. Add small amounts of sodium until you achieve a pH>3.6 by measuring with pH indicator paper or a pH meter. Sodium citrate and pH Indicator Paper are included in the Molecular Gastronomy Essential Kit, the Molecular Gastronomy Premium Kit and the Molecular Gastronomy Ultimate Kit.

Correcting Free Calcium Content for Basic Spherification: Basic Spherification cannot be used with ingredients that have calcium content (free calcium ions) as it will react with the sodium alginate and gel before you pour the flavored ingredient in the calcium bath. If the calcium content is not too high, you can add a sequestrant such as sodium citrate to the flavored liquid if the pH is above 4.5 before mixing with the sodium alginate. The sodium citrate will bind to the free calcium ions so they are not available to react with the sodium alginate. If you have an ingredient with calcium content, it is better to use Reverse Spherification.

Removing Air Bubbles: Mixing sodium alginate with any liquid usually results in many air bubbles trapped in the resulting dense liquid. Air bubbles are a problem because they may create weak points in the sphere membrane that will break or leak easily. Also, air bubbles will increase the buoyancy of the sphere in the bath, making it float and not allowing it to sink and be completely covered by the calcium bath. Finally, it will affect the presentation, making the color of the flavorful liquid pale.

Here are a few ways to eliminate the air bubbles:

Let it rest: this is the most common method. Just let the solution with sodium alginate rest in the fridge. Depending on the density of the liquid, this may take 1 to 24 hours. Pass it through a fine sieve: to speed up the process, you can pass the sodium alginate solution through a fine sieve. Let the liquid flow through it on its own without applying pressure. You may have to repeat this process a few times. Use a vacuum chamber: these are expensive but if you have access to one, you can place the liquid in the vacuum chamber to eliminate the air bubbles. This is definitely the fastest method. Using a magnetic stirrer instead of a blender will prevent the formation of air bubbles.

The Reverse Spherification

The Reverse Spherification technique consists of submerging a liquid with calcium content in a bath of sodium alginate. If the juice or flavored liquid does not naturally contain calcium, Calcium Lactate or Calcium Lactate Gluconate is added. There is also a variation of this technique, Frozen Reverse Spherification that reduces preparation time, does not require practice and results in perfectly shaped spheres of consistent size.

Pros of Reverse Spherification: Reverse Spherification is more versatile than Basic Spherification as it can make spheres with almost any product. It is best for liquids with high calcium content or alcohol content which makes them great for cocktails and dairy products like cheese, milk, cream and yoghurt. The resulting sphere is long-lasting and can be stored for later consumption. Contrary to Basic Spherification, the process of jellification can be stopped when the sphere is removed from the sodium alginate bath and rinsed with water. This is very convenient when entertaining friends as you can prepare them ahead of time. This also allows you to macerate the spheres overnight to add some extra flavor (e.g. in aromatized olive oil or truffle water). Reverse Spherification results in a sphere with a thicker membrane than with Basic Spherification. Thanks to this, the resulting spheres can be manipulated easily, they conserve their shape better when plated (spheres produced with Basic Spherification flatten and acquire an orb or egg yolk shape when plated) and can be used in more ways (e.g. as fillings in sponge cakes or mousses). Jellification still occurs when the main ingredient liquid has some acidity. This is because in Reverse Spherification the jelling process occurs on the surface of the sphere as the sodium alginate fails to penetrate it. A translucent layer of gel is created around the main ingredient. In Basic Spherification, the gelling process occurs internally and has the color of the main ingredient. The main ingredient consistency and flavor is not altered by the addition of calcium lactate gluconate and calcium lactate as they have no discernable flavor and dissolve in liquid without altering its density. This is the reason why in Reverse Spherification we don’t use calcium chloride which is very salty.[5]

Cons of Reverse Spherification: The thicker membrane of these spheres is more evident in your palate. You still get the “pop” sensation but in addition to the liquid you also feel the solid jelly in your mouth. The sodium alginate bath needs to rest for 12-24 hours before using it for Reverse Spherification to eliminate the air bubbles created by the process of dissolving the sodium alginate with the immersion blender. The flavored liquid may need to be thickened with Xanthan Gum and if air bubbles get trapped in the process, you may need to wait a few hours to eliminate them. It is a little harder to get a perfect sphere on the plate with Reverse Spherification than with Basic Spherification. You are pouring the main ingredient into a viscous bath, the spheres tend to stick to each other if you don't separate them in the bath and the thicker membrane maintains the shape better which is great if you were able to create a perfect sphere but not if your spheres are "deformed". Frozen Reverse Spherification solves this problem if the main ingredient can be frozen. Learn about Frozen Spherification here. Reverse spherification is not great for making caviar as the main ingredient needs to be thickened to be able to penetrate the dense sodium alginate bath and cohere into a sphere.

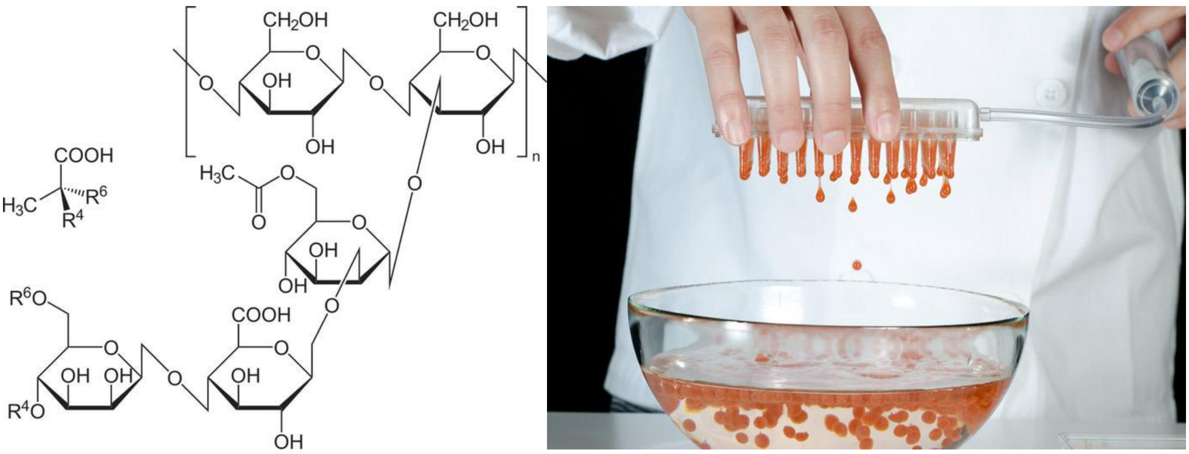

Figure-7: Xanthan Gum as rheology maker in spherification

Adjusting the Flavored Liquid Density: When you pour the liquid into the bath, the spherical shape forms thanks to surface tension. The density of the flavored liquid and the bath affect the surface tension and the resulting shape. If the flavored liquid is to thin, it will fail to penetrate the dense bath surface and will spread in the bath and fail to hold its shape. If it is too thick, it will fail to round evenly to form a nice sphere. The right consistency is that of thick cream. Xanthan Gum is usually use to thicken the flavored liquid until the appropriate viscosity is obtained. Xanthan gum is a polysaccharide secreted by the bacterium *Xanthomonas campestris*, used as a food additive and rheology modifier, commonly used as a food thickening agent (in salad dressings, for example) and a stabilizer (in cosmetic products, for example, to prevent ingredients from separating). It is composed of pentasaccharide repeat units, comprising glucose, mannose, and glucuronic acid in the molar ratio 2:2:1. It is produced by the fermentation of glucose, sucrose, or lactose. After a fermentation period, the polysaccharide is precipitated from a growth medium with isopropyl alcohol, dried, and ground into a fine powder. Later, it is added to a liquid medium to form the gum. One of the most remarkable properties of xanthan gum is its ability to produce a large increase in the viscosity of a liquid by adding a very small quantity of gum, on the order of one percent. In most foods, it is used at 0.5%, and can be used in lower concentrations. The viscosity of xanthan gum solutions decreases with higher shear rates; this is called shear thinning or pseudoplasticity. This means that a product subjected to shear, whether from mixing, shaking or even chewing, will thin out, but, once the shear forces are removed, the food will thicken back up.

In salad dressing, for example, the addition of xanthan gum makes it thick enough at rest in the bottle to keep the mixture fairly homogeneous, but the shear forces generated by shaking and pouring thins it, so it can be easily poured. When it exits the bottle, the shear forces are removed and it thickens back up, so it clings to the salad. Unlike other gums, it is very stable under a wide range of temperatures and pH. In foods, xanthan gum is most often found in salad dressings and sauces. It helps to prevent oil separation by stabilizing the emulsion, although it is not an emulsifier. Xanthan gum also helps suspend solid particles, such as spices. Also used in frozen foods and beverages, xanthan gum helps create the pleasant texture in many ice creams, along with guar gum and locust bean gum. Toothpaste often contains xanthan gum, wherein it serves as a binder to keep the product uniform. Xanthan gum also helps thicken commercial egg substitutes made from egg whites, to replace the fat and emulsifiers found in yolks. It is also a preferred method of thickening liquids for those with swallowing disorders, since it does not change the color or flavor of foods or beverages at typical use levels.

Xanthan gum is also used in gluten-free baking. Since the gluten found in wheat must be omitted, xanthan gum is used to give the dough or batter a stickiness that would otherwise be achieved with the gluten. In the oil industry, xanthan gum is used in large quantities, usually to thicken drilling mud. These fluids serve to carry the solids cut by the drilling bit back to the surface. Xanthan gum provides great "low end" rheology. When the circulation stops, the solids still remain suspended in the drilling fluid. The widespread use of horizontal drilling and the demand for good control of drilled solids has led to its expanded use. It has also been added to concrete poured underwater, to increase its viscosity and prevent washout. In cosmetics, xanthan gum is used to prepare water gels, usually in conjunction with bentonite clays. It is also used in oil-in-water emulsions to help stabilize the oil droplets against coalescence. It has some skin hydrating properties. Xanthan gum is a common ingredient in fake blood recipes, and in gunge/slime.[6]

Frozen Reverse Spherification

The spherification technique, created by molecular gastronomy Chef Ferran Adriàin 2003, consists of a controlled jellification of a liquid which forms spheres when submerged in a bath. There are a few variations of the spherification process: Basic Spherification, Reverse Spherification and Frozen Reverse Spherification. Frozen Reverse Spherification is pretty much the same process as Reverse Spherification but with an extra freezing step. Freezing the main ingredient in hemispheric silicone molds reduces the preparation time, does not require practice and results in perfectly shaped spheres of consistent size. As in Reverse Spherification, this technique consists of submerging a liquid with calcium content in a bath of sodium alginate. But instead of using a spoon to pour the main ingredient into the alginate bath, a hemispheric mold is used to freeze the calcium mixture and then the frozen hemispheres are popped into the bath. As the edge of the hemisphere starts to melt, the calcium in the mixture reacts with the alginate in the bath to produce the membrane. After removing the spheres from the alginate bath, they are rinsed in a clean water bath.

The length of time that you need to leave the sphere in the bath is a little longer than in Reverse Spherification and it depends on how fast the frozen hemisphere thaws. To speed up the process, you can use a warm bath. If you use a warm alginate bath it can take from 2 to 5 minutes for the membrane to form. Creating a perfect sphere using a spoon is an art and it takes time and patience. With Frozen Reverse Spherification, all the spheres will be the same size and perfectly round. Preparation time is shorter but you need to be able to prepare the mix in advance and allow it to freeze in the mold for several hours. Another benefit is that it is not necessary to thicken the main ingredient to create the spheres thus having a better release of liquid in the mouth when the sphere breaks. You may still want to slightly increase the viscosity so they can hold the spherical shape better when plated. The hemispheric silicone molds are perfect for frozen reverse spherification (buy silicone mold). The only limitation of this technique is that you can only use it with ingredients that can freeze or do not get spoiled by freezing. So this technique wouldn't be appropriate for alcoholic preparations for example and of course, you need a silicone mold of bite size hemispheres.

10 Tips to Create a Perfect Sphere

Getting started with the spherification technique created by Ferran Adriàat el Bulli is not difficult but creating a perfect sphere shape requires some practice. These are a few tips to help you master the spherification technique and impress your diners with a perfect sphere: **1- Get the right viscosity. 2- Do not use tap water**. **3- Use a spherical spoon**. **4- Use a flat pan for the bath**. **5- Fill the bath container up to the top**. **6- Pour the liquid carefully**. **7- Don't let the spheres float at the top**. **8- Flip the spheres occasionally while in the bath**. **9- Clean your spoons**. **10- Keep the bath clean**.[7]

Spherification Caviar Tips

With the spherification technique you can make little spheres that resemble the shape of real caviar. The spherification caviar is made by releasing small droplets of the flavored liquid into the calcium bath using a syringe or a Caviar Maker. Making spherification caviar is fun but it can be a draining process to make enough for a few cocktails or dishes one drop at a time using just a syringe or squeeze bottle. With the Caviar Maker you can now multiply the production by 96 times with no extra effort! Here are some tips to master this fun molecular gastronomy technique created by Ferran Adrià and El Bulli team.

1- Use Basic Spherification: spheres tend to stick together when made with the Reverse Spherification technique so it is better to use Basic Spherification when creating spherification caviar since you have to produce many little spheres and they will inevitably come in contact with each other. The low viscosity of the bath in Basic Spherification will also make it easier to form small "caviar" spheres as it will allow the droplets to penetrate the bath surface with their small weight.

2- Release the droplets from the right height: to avoid getting flattened or oval spheres, the droplets should have enough distance from the surface of the calcium bath so that they have enough time to cohere into a sphere and enough speed to penetrate the surface and sink. Don't go too high up or the impact with the bath will deform them and you will end up with flattened caviar. You can also try a more diluted calcium bath to give time for the drop to cohere in the bath.

3- Apply constant pressure to the syringe pump: to obtain caviar spheres of consistent size, push the syringe pump at constant pressure and slow speed and allow the droplets to break away from the tip of the syringe on their own without tapping or shaking the syringe. Try holding the syringe horizontally to obtain more control and slightly larger caviar spheres. This process is much easier with the Caviar Maker as the results do not vary by how you press the syringe pump.

4- Regulate main ingredient acidity: basic spherification does not occur if the main ingredient is acidic (PH<3.6).

You'll also have trouble dissolving the sodium alginate if the acidity is high. Add some sodium citrate to reduce the acidity but be careful with the amount you add or the main ingredient will become too salty.

5- "Cook" the spheres for less than 1 min: you want the caviar spheres to have liquid inside so just let them rest in the bath for a minute or less or they will become a gel ball. This could be a challenge if you only have one syringe and you are planning to make enough caviar for a few servings. At the speed droplets come out of one syringe you probably need a minute to make enough caviar for one serving so this means the first caviar sphere will be ready when the last droplet touches the bath for the first time. And because all the little spheres get mixed in the bath, you usually fish them out of the bath all together. An easy solution is to produce them in batches and serve them to one diner at a time. Another solution is to use an array of syringes or a Caviar Maker to produce a large quantity of caviar in a short period of time.

6- Use a bowl for the bath and a round sieve to fish the caviar: this will make it easier to fish all the caviar at once. If you use a rectangular container it will be harder to catch the spheres in the corners.

7- Serve immediately: remember that spheres produced with Basic Spherification continue to gel even after they are removed from the calcium bath and rinsed with water. You need to serve them immediately after preparation to delight your diners with a caviar sphere with subtle membrane and liquid inside.[8]

Figure-8: Mouthwatering popping boba

CONCLUSION

Molecular gastronomy cooking could sometimes require expensive equipment and hard to find ingredients. This is not the case with spherification recipes. Some of the ingredients used for spherification were hard to find in small amounts years ago but now they are easily available thanks to the popularity of this molecular gastronomy technique created by Ferran Adriàat el Bulli. The best way to start experimenting with molecular gastronomy techniques is to buy a molecular gastronomy kit. This is the most affordable way of getting a wide variety of ingredients at a reasonable price. Keep in mind that you usually need one or two grams and sometimes even a fraction of a gram of each ingredient for most recipes so think twice before buying in pounds. **Spherification Ingredients: Sodium Alginate, Calcium Chloride, Calcium Lactate, Calcium Lactate Gluconate, Sodium Citrate, Xanthan, Dosing spoons, Collecting spoon, Syringe, pH Indicator Paper, Immersion blender, Fine Skimmer, Fine Sieve and Cheesecloth, Appetizer spoons.**

So-called spherification is based on a food re-engineering manufacturing process. For years, the food industry has been using this process to re-engineer fruit, vegetable or meat purees into pieces whose form and texture are very similar to the basic ingredient. For example, what appears to be a piece of bell pepper stuffed into pitted olives is actually a gelled and remolded puree. By doing so, the industry is able to maintain consistent uniformity in the appearance of products. In addition, by using puree rather than whole foods, the industry can achieve substantial cost savings. One thing is for certain: when Catalan chef Ferran Adrià of the famous restaurant El Bulli in Spain adopted and perfected this technique, he had something else in mind other than recycling raw material! In molecular gastronomy, spherification is now defined as the encapsulation of a liquid inside different sized spheres that burst in the mouth. The wall trapping the liquid inside the sphere consists of a gel formed by a process similar in some respects to the one described in the preceding section on gelling. The additive used is sodium alginate, and just like in the gelling process using carrageenans or gellan gum, the presence of ions is essential for the formation of the gel. In the case of a sodium alginate gel, the presence of calcium ions is required so that the long alginate molecules can align and bind to finally form a gel. To better understand the ability of sodium alginate to form a gel, let's take a closer look at the molecule. Alginate reacts with any calcium that naturally occurs or that has been added to the ingredient to be spherified. For example, we could make a pudding by simply adding sodium alginate to a preparation of milk and sugar, as milk is naturally rich in calcium. Applying this principle, we can precisely control the moment when the calcium and alginate come into contact and thereby diversify the liquids to be gelled and the forms obtained. Depending on the source of calcium ions, two types of spherification can be used. Basic spherification & Reverse spherification: Both techniques can be used to create different sized spheres. However, basic spherification is preferred to create small balls, or caviar, whereas reverse spherification is the preferred method to form larger spheres, also called flavor bubbles.

Basic spherification: Basic spherification consists in immersing a liquid containing sodium alginate in a high-calcium bath. Calcium ions then migrate from the sphere’s exterior to its interior. As a large amount of calcium ions remains present in the caviar’s wall, even a water rinse will not completely slow down the gelling of the wall, which will thicken until the sphere’s interior is completely gelled. Since an in-the-mouth flavor burst is usually desired, it is recommended to serve the caviar as quickly as possible after its formation. It is important to note that the addition of the sodium alginate solution to the preparation to be transformed significantly dilutes it. So, for maximum flavor, be sure to transform solutions that are highly flavorful; otherwise the taste will be rather bland. Sodium alginate will also thicken the preparation. Since the preparation is thicker and less intense in flavor, basic spherification is not recommended for creating large flavor bubbles. However, it is the most practical technique to create small beads, commonly known as flavor caviar.

Reverse spherification: As its name suggests, compared with basic spherification, reverse spherification involves a permutation in the process of immersing sodium alginate and calcium salt. The principle is to pour a high calcium solution in a bath in which sodium alginate has been dissolved. Calcium ions then migrate from the sphere’s interior to its wall. Unlike what happens in basic spherification, it is possible to slow down the wall’s thickening process, since rinsing removes excess sodium alginate on the sphere’s contours. In the absence of alginate molecules, calcium ions have no effect and the sphere’s interior remains liquid. Once rinsed, flavor bubbles can be stored and served sometime after their formation. Dissolving sodium alginate in a solution significantly thickens it. The sodium alginate bath is therefore very thick and some solutions that are too watery simply cannot penetrate it: the result will look more like a deformed lump of gel than a sphere! When choosing preparations to be spherified, it is best to work with liquid bases that are naturally thick and high in calcium such as cream, yogurt and certain purees. It is also possible to thicken the preparation to be transformed using a thickening agent such as xanthan gum to minimize the density gap with the sodium alginate bath. However, to spherify very watery solutions, frozen reverse spherification is recommended.

Frozen reverse spherification: Freezing solutions enables greater precision in the final form and overcomes many of the limitations and constraints of spherification. The technique is straightforward and very similar to reverse spherification. A pinch of calcium salt is first added to the preparation to be transformed, after which the preparation is molded and frozen. The ice cubes thus produced are then immersed in a sodium alginate bath and rinsed. You no longer have to worry about the preparation’s texture, since the ice cubes easily penetrate the surface of the sodium alginate bath. So you can transform completely liquid solutions for an even more spectacular in-the-mouth effect!

Other characteristics: Sodium alginate-based gels are irreversible and therefore can be served hot. To do this, simply immerse the spheres in hot water and wait until the heat is absorbed. In addition, they are resistant to freezing and thawing. The fact that they can congeal cold without prior heating is also a certain advantage. Nevertheless, it is important to note that the spherification process may be hindered by a high level of acidity or alcohol.

Frozen reverse spherification avoids most of these contraindications, obviously provided that the preparation can be frozen. Finally, be wary of unknown calcium sources that could congeal the preparation without warning. If the tap water is particularly high in calcium, it would be preferable to use bottled water. Also, do not pour the alginate bath down a narrow pipe; otherwise, it could form a blockage!

REFERENCES

1. Cassi Davide. Science and cooking: the era of molecular cuisine, EMBO Reports, European Molecular Biology Organization, 12: 191-196, 2011.
2. Potter Jeff. Cooking for Geeks: Real Science, Great Hacks, and Good Food. O'Reilly Media, Inc, 2010.
3. http://www.molecularrecipes.com/spherification-class/
4. Heston Blumenthal: http://www.bloomsbury.com/uk/the-big-fat-duck-cookbook-9780747583691/
5. McGee, Harold, The Curious Cook. North Point Press, Berkeley, 1990.
6. McGee, Harold, On Food and Cooking: The Science and Lore of the Kitchen. Scribner, New York, 2004.
7. This Herve, Building a Meal: From Molecular Gastronomy to Culinary Constructivism, Columbia University Press, 2009.
8. https://poppingboba.com/