




Molecular Gastronomy


What is molecular gastronomy?

Modernist cooking, science and cooking... using science and technology to make food... the more unique versions of foods the more "molecular"

Picno Marshmallow Cocktail Liquid Pea Sphere Oak Moss Vapor



"The scientific study of deliciousness"
- Harold McGee



History... aka who tells the tale!


Most commonly repeated

Molecular gastronomy was coined in 1992 by Hungarian physicist Nicolas Kurti and Herve This (who like to be considered the father of Molecular Gastronomy)


While chefs/cooks were experimenting with scientific tools to make unique foods, a group of scientists and cooks, bakers created a food and science themed meeting...

But who really said what?





But that name

Elizabeth Cawdry Thomas
- London Cordon Bleu alumna
- Instructor at cooking school in Berkeley




Kurti was part of a core of scientists and culinary experts that found funding to bring the mix of science and cooking to Erice Italy.

Harold McGee Shirley Corriher

After Thomas attended a scientific conference with her physicist husband in Italy, dinner discussions led to the undervalued idea of science of cooking with other scientists. Encouraged, she organized a workshop which would be directed by Kurti. The initial conference name "science and gastronomy" was thought frivolous and a group of participants voted on the name "Molecular Gastronomy". Corriher tells that it was to get the attention for funding. McGee writes Kurti wasn't part of this first meeting.




Spherification

Shaping liquids into spheres using gels for a unique visual and culinary experience

Direct and Reverse Spherification

- Use low pH, calcium and sodium alginate to make thin gel membranes




MOLECULAR COCKTAILS: SPHERIFICATION

Spherification is a technique that can be used to make small caviar-like spheres of flavour which then float in a cocktail and burst in the mouth when they are drunk. Two different techniques can be used: spherification, and reverse spherification.

THE METHOD

- First, sodium alginate is dissolved in the liquid to be spherified. If the liquid is too acidic (pH < 3.0), the sodium alginate will convert into insoluble alginate acid, so this must be avoided.
- The liquid from step one is dropped into a bath containing calcium chloride, calcium lactate, or calcium lactate gluconate. This forms a membrane around the spheres.
- The spheres are removed from the bath after around a minute and then rinsed in distilled water. They are then ready to be served and can be placed into the cocktail!

BUBBLED UP BELLINI

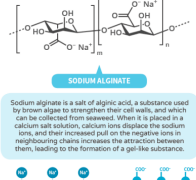


Sparkling wine with spheres of fruit/vegetable extract. This is one tasty dog - these strawberries from the oak.

THE SCIENCE

SODIUM ALGINATE

Sodium alginate is a salt of alginic acid, a substance used by brown algae to strengthen their cell walls, and which can be collected from seaweed. When it is placed in a calcium salt solution, calcium ions displace the sodium ions, and their increased pull on the negative ions in neighbouring chains increases the attraction between them, leading to the formation of a gel-like substance.




SPHERIFICATION

- Sodium alginate bath used
- Calcium salt bath used
- Eventually gels whole sphere

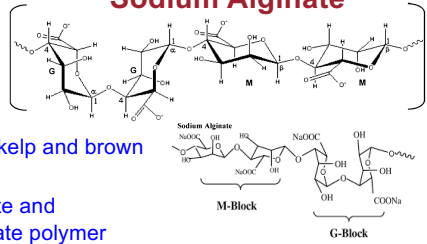
REVERSES SPHERIFICATION

- Calcium salt in liquid
- Sodium alginate bath used
- Works for acidic liquids
- Gel only forms at membrane

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Sodium Alginate



Isolated from kelp and brown seaweed.

- Glucuronate and Mannuronate polymer
- Carboxyl groups of alginate will cross link forming a long polymer gel

Alginate a whole family of linear copolymers containing blocks of (1,4)-linked β-D-mannuronate (M) and α-L-guluronate (G) residues. The blocks are composed of consecutive G residues (GGGGG), consecutive M residues (MMMMM), and alternating M and G residues (GMGMGM)

Used as a hydrogel to deliver Drugs in slow release

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pH! R-COOH remember we use acidic juices!

- Calcium ions are added and create links between the individual polymer chains of the alginate.
- These cross-links cause the polymer chains to entangle and are therefore restricted in their motion.
- Restricted motion increases the viscosity of the solution and traps water in its networked structure.

Before alginate can thicken or gel a liquid, it needs to be evenly dispersed into that liquid (with no lumps) and hydrated (so that each molecule is surrounded by water).

This sounds simple, but it sometimes can prove difficult.

Dispersing alginate into hot liquid tends to cause it to hydrate and gel before the powder has been dispersed. The resulting lumps are unpleasant and cause inconsistent results. For this reason, it's always best to blend alginate into a very cold liquid or to first dry blend it with an ingredient like sugar.

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Direct Spherification

Alginate Solution + Flavoring

Calcium Ion Bath

- As alginate drops hit the calcium solution they immediately gel via cross-linking.
- Shell is formed at the interface of the 2 solutions.
- Calcium ions still exist in the network's water.

Problems With Direct Spherification

- Time sensitive
- Liquid interior continues to gel.
- Sensitive to acid.

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Reverse Spherification

Calcium Ions + Liquid Flavorings

Alginate Bath

Advantages of Reverse Spherification

- Spheres can be isolated and interior does not solidify.
- Not sensitive to pH
- Calcium limited!

- As drops of liquid hit the alginate, shell is formed.
- Shell is formed on outside at interface.
- Calcium ions diffuse out of liquid and hit the interface.

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Reverse

Direct

The Science of Cooking

Foods as Air

Foams – basic emulsification as an “air” that dissolves in your mouth

- Colloidal system (dispersion of particles in an aqueous medium) where particles are gas bubbles and the medium is a thin liquid (gas in liquid emulsions)
- These emulsions are stabilized into a cellular spongy or rigid for my emulsification

Ostwald ripening: smaller bubbles merge as gasses diffuse through liquid. Driven by higher pressure in small bubbles than larger bubbles

Coalescence: limited by strength of liquid

Culinary foams are often juices or vegetable purees, soups and stock bases

“thicker foams” include whipping creams, meringue, latte, and mousse

Emulsifiers include lecithin and proteins (gelatin)

- Ampathatic non-polar portion lines up against air with polar end H bonds to water
- Viscosity to slow liquid – air movement stabilizes.
- Solidifying foams with heat (meringue) traps the air
- Gels stabilize to near solid state (marshmallows)

MOLECULAR COCKTAILS: FOAMS & AIRS

Foams and airs are often utilised to modify the texture and flavour of cocktails. They are usually created by the use of a number of agents broadly referred to as surfactants. Both the agents and techniques used affect the type of foam created.

THE METHOD

1. A surfactant is added to the cocktail mixture, or the liquid from which the foam will be made. A number of different agents can be used as surfactants (see below).
2. The foam can be generated using a hand blender or shaking in a cocktail shaker. Another method is to use a cream whipper, which forces nitrous oxide (N₂O) into the liquid.

THE SCIENCE

HYDROPHILIC SECTION

AMPHIPHILIC SECTION

Surfactant molecules contain both hydrophilic (water-loving) and hydrophobic (water-hating) regions. They arrange themselves around air bubbles in the water, with the hydrophilic sections dissolving in water and helping to stabilise the bubbles, preventing them from popping.

AGENTS TO MAKE FOAMS

The agent chosen depends on the type of foam required. Below are four common agents used to create cocktail foams.


- EGG WHITE**: 50% protein. Meringue foam.
- LECIITHIN**: From egg yolk or soy. Meringue foam.
- PROTEIN**: From animal collagen. Foams, acidic foams.
- AMPHIPHILIC SECTION**: Amaranth and Xanthan gum. Ripper. Whisk with lemon, sugar and grape extract. Long and fresh like the French of old air.
- SHAKER**: Aerates the cocktail to generate fine, stable cells. Chilling by shaking occurs more quickly than chilling by stirring.
- HAND BLENDER**: Whips air in to generate the foam, then liquid after the foam has been generated and air from the cocktail.
- N₂O WHIPPER**: Uses N₂O cartridges. Pressure in the cartridge can be up to 8 times atmospheric pressure, making N₂O dissolve.

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Gelification



It is the process of turning a liquid into a viscous gel with solid, jelly-like material.

"liquify foods, solidify liquids" for a unique delivery of flavor"

Examples of gelification agents include:
Agar agar, carrageenan, gelatin...

Agar agar – from red algae

O[C@H]1[C@H](O[C@@H]2[C@@H](O)[C@H](O)[C@@H]2O)[C@H](O)[C@H](O)[C@H]1O

Agar agar

λ -carrageenan

One form of carrageenan – from seaweed

MOLECULAR COCKTAILS: GELIFICATION

Gelification is the process of turning a substance into a gel or jelly. This can be done using a variety of agents, all of which are types of hydrocolloids. Different agents can be used in different situations, and give different properties to the resulting gel.

THE METHOD

- The gelification agent is dispersed in the liquid to be turned into a jelly. A number of different agents can be used (see below), many require heating to fully dissolve in the liquid.
- If heating is required, any alcohol is added after so it is not lost. The mixture is poured into a jelly mould and cooled to the gelling point, which is different for different agents.

GELIFICATION AGENTS

AGENTS	AGENTS	AGENTS
Agar agar	SPECTRIN	BUSH AND CELLULOSE
Agarose	Agarose	Agarose
Agarose	Agarose	Agarose

Eatable cocktails because eating's not always heating. The Long Island jelly is a blend of vodka, gin, rum, brandy and triple sec, with a coke bottom. The Bramble Jell contains gin and lemon with a blackberry liqueur.

THE SCIENCE

SUSPENSION → GELIFICATION

Green strands = polymeric/hydrolyse molecules in gelification agent

Gelification agents are generally made up of either long protein or carbohydrate molecules. When heated and dispersed in water, these molecules unfold. As the gel is cooled to the gelling agent's setting point, they tangle and interleave to form a solid network, trapping molecules of water within it and forming the gel or jelly.

FORMING THE GEL NETWORK

— protein/carbohydrate chains
..... intermolecular forces or cross-links between chains

You might wonder what holds the solid network in gels together and stops the interlinked chains simply sliding to the bottom of the liquid. This is due to attractive forces between the chains holding them together at certain points, whilst repulsive forces hold them apart at others.

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Meat Glue

Transglutaminase – calcium dependent enzyme isolated from clotting factors from blood, bacteria or plants.

- Generates a stable isopeptide bond of lysine and glutamine between two proteins (crosslinker)

NC(CCC)C(N)=O + NCC(N)C(N)=O >> NCC(N)C(N)C(=O)N(CCC)C(N)=O

Glutamine residue (gamma-carboxamide group) of one protein

Lysine residue (epsilon-amino group) of second protein

Covalent isopeptide bond: ϵ - γ -glutamyllysine

Lysine Aspartate/Asparagine

Isopeptide Bond

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Simple nucleophilic attack!

Similar to other enzyme regulate reactions.

A

Glutamine (C277) attacks H335, displacing H₂S. Thiols are nucleophilic, and H₂S is a good leaving group.

B


[Closed, inactive form] → [Open, active form]

β -barrel1, β -barrel2, C-term, β -sandwich domain, N-term, Catalytic core


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Meat Glue Examples


Transglutaminase, also called **meat glue**, is an enzyme that can be used to bind proteins to make uniform portions of fish filet, tenderloins, etc. that cook evenly




Imitation crab



Yep and hot dogs



Shrimp noodles!



ORIGINAL RECONSTRUCTED

Mock filet mignon

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Deconstruction

This technique involves breaking down the elements of a dish and rebuilding the presentation. Usually, a deconstructed dish consists of multiple components of a dish that are presented together.



For example, you can serve a small cake next to the frosting or topping with bits of dehydrated marshmallow on the side.

This technique provides a basis for developing a unique presentation and plating method for a molecular gastronomy creation.



Sous Vide

French for “under vacuum”. But not really - Circulating water bath with precision control. Food is NOT immersed in the water (that is par boiling) but is in a bag with air removed.

It is a way to heat the entire food at the “core” temp to denature protein without losing the water holding capacity. Also pasteurizes food.





Not “new” nor “boiling”

Used in restaurants to prepare food with higher shelf life and fast production '90s

- Used in top restaurants since the 70's


Efficient heat transfer (water vs air as a medium) and increases shelf-life with elimination of contamination during storage

Prevents oxidation and evaporative losses and volatile flavorants lost during traditional cooking

Pasteurization at lower temps for repeatability

Makes tough cuts traditionally braised or boiled tender with medium-rare doneness.

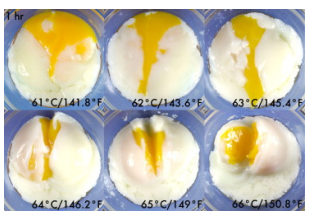




Temp and Time

Denaturing “melting” proteins is one of the three reasons food is cooked.

- Softens the meat to the tooth.
- Connective tissues and collagen as well as myosin are all denatured but partially in a med-rare steak




61.5 °C/143 °F: conalbumin denatures and causes the egg white to form a loose gel;

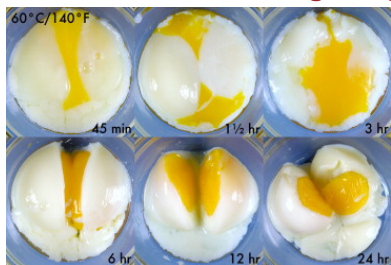
64.5 °C/148 °F: livetin denatures and causes the egg yolk to form a tender gel;

70 °C/158 °F: ovomucoid denatures and causes the egg white to form a firm gel (the egg yolk also coagulates around this temperature);


84.5 °C/184 °F: Ovalbumin denatures and causes the egg white to become rubbery



Fixed time, increasing temp



Egg cooked at 60 °C/140 °F for 45 min, 90 min, 3 h, 6 h, 12 h, and 24 h. The texture of the 3-h-egg's yolk was noticeably thicker than the 90-min-egg's yolk, which was thicker than the 45-min-egg's yolk.



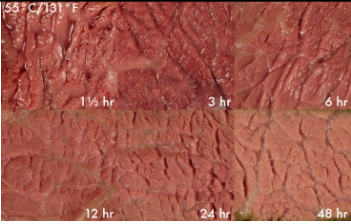
Muscle (beef, pork, chicken) is ~75% water, 20% protein & 5% fat (varies on cut...)

Connective fiber tissues denature at different rates.

Collagen content and primary sequence of fish vs beef provides a different melting point

Results in less connective tissues and tender meat


- At lower temps, proteases also are active.



55 °C/131 °F

During heating, the **muscle fibers** shrink transversely and longitudinally, the sarcoplasmic proteins aggregate and gel, and connective tissues shrink and solubilize.

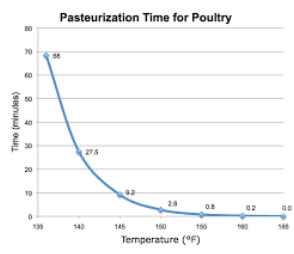
- muscle fibers begin to shrink at 35–40 °C/95–105 °F up to 80 °C/175 °F.
- The aggregation and gelation of sarcoplasmic proteins begins around 40 °C/105 °F to 60 °C/140 °F.
- Connective tissues start shrinking around 60 °C/140 °F but contract more intensely over 65 °C/150 °F.
- The slow changes mainly increase tenderness by dissolving collagen into gelatin and reducing inter-fiber adhesion.



But is it safe?

Time and temp

- kind of
- CV = CV



Each dot is how long it takes at a given time and temp to reduce pathogen with a 7-log₁₀ lethality. Reduction that ensures 1 of 10 million bacteria will survive...

 **Sooo what else?**

LN2 hamburgers?



 **Finish it!**

Maillard and caramelization

