Molecular Cooking

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In January 2003, the INICON project, which was funded by the European Union (EU), commenced under the Innovation and SME 5th EU-Research Framework. The focus of the project was to introduce innovative technologies in cooking. As described by TTZ-Bremerhaven (2005), there was a technology transfer from the Molecular Gastronomy Group INRA (France) and TTZ Bremerhaven (Germany) toward four chefs from El Bulli (Spain), the Fat Duck (UK), Grashoff (Germany) and Au Crocodile (France), and the culinary school ESCF Ferrandi (France), working together with food industry representatives from Alpha-Tec (plant manufacturer, Germany), Cosmos Aromática (flavour manufacturer, Spain) and Iberagar (natural hydrocolloid manufacturer, Portugal).

Three years after the project finished, molecular cooking was defined by This (2008) as a culinary technique using ‘new’ tools, ingredients and methods (mainly from chemistry and physics laboratories), whereas molecular gastronomy is a scientific discipline, which is part of food sciences. Subsequently, Cassi (2011) proposed defining ‘molecular cuisine’ as a type of cuisine that arises from collaborations between chefs and scientists. The term ‘molecular cuisine’ has sometimes been criticized, but the reason for using it was that innovative cuisine had to be distinguished from science, and in particular from Molecular Gastronomy (This, 2013).

Early adopters of molecular cooking were the chefs Raymond Blanc (Oxford, UK), Christian and Philippe Conticini (Paris), Shirley Corriher (USA), Fritz Blanck (USA), Elizabeth Thomas (USA), Ferran Adria (Spain), Heston Blumenthal (UK), Pierre Gagnaire (France), Andoni Luis Aduriz (Spain) and Denis Martin (Switzerland) (Myhrvold et al., 2011a; Myhrvold and This, 2018).

Tools

In many cases, new tools are designed for specific applications in the kitchen, e.g., caviar boxes for spherification. Other tools, such as a rotary evaporator, are normally found in a laboratory, but it is now not uncommon to see them being used in a restaurant kitchen. Historically, the order of appearance in kitchens was first thermocirculators, followed by siphons, liquid nitrogen, decanting bulbs, rotary evaporators and eventually, ultrasonic probes. Table 126.1 lists examples of such tools, and detailed descriptions are provided by authors such as Blumenthal (2009). Myhrvold et al. (2011b) and Potter (2015). Catalogues from companies such as MSK (2019) and Sosa (2018), which specialize in providing equipment for molecular cooking, give details of a broad array of equipment and accessories.

Ingredients

The number and type of speciality ingredients associated with molecular cooking have steadily increased since 2003, and there have been numerous publications about their chemical and physical properties and their uses, such as those by Blumenthal (2009), Lersch (2014), Myhrvold et al., (2011c), Sanchez (2016) and This (2014). Company catalogues by ingredient suppliers include those such as Iqemusu (2017), Louis François (2019), MSK (2019), Texturas (2012) and Sosa (2019).

Common ingredient classes include hydrocolloids, which can be gelling agents or gums, acids, salts, chelating agents, colours, enzymes, emulsifiers and stabilizers, flavourings, foaming

TABLE 126.1

<table>
<thead>
<tr>
<th>General</th>
<th>Specific</th>
<th>Measurement</th>
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<td>Driers</td>
<td>Aerator – fish tank bubbler</td>
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<td>Dehydrator</td>
<td>Anti-griddle</td>
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<tr>
<td>Freeze-drier</td>
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<td>Spray-drier</td>
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<td>Vacuum oven</td>
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<td>Mixers</td>
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<td>Hand-blender</td>
<td>Multi-aromatizer</td>
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<td>Pacojet</td>
<td>Rotary evaporator</td>
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<tr>
<td>Thermomix</td>
<td>Siphons – nitrous oxide or carbon dioxide</td>
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<td>Colloid mill</td>
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<tr>
<td>Homogenizer</td>
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<td>Separators</td>
<td>Sous vide circulating water</td>
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<tr>
<td>Centrifuge</td>
<td>bath, immersion circulator</td>
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<tr>
<td>Filtration unit</td>
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agents, odorants, sweeteners and ingredients to provide acoustic sensations. Figure 126.1 provides examples of ingredients that can be used to boost or enhance certain sensorial sensations, while of course, combinations allow heightened multi-sensory experiences.

There are numerous recipes available online or in books (Adria et al., 2008; Blumenthal, 2009; Myhrvold et al., 2011b; MolecularR, 2019a) that incorporate these ingredients. Often, these are accompanied by YouTube clips that guide the chef through the methods step by step.

Famous recipes incorporating some of the ingredients in Figure 126.1 include Spherical-I green olives (Adria et al., 2008) and Hot and Iced Tea (Blumenthal, 2009). In the former, Ferran Adria used sodium alginate, xanthan gum and calcium salt to create spherical olives from a green olive juice (Adria et al., 2008). In the latter, Heston Blumenthal used gellan gum, sodium citrate, calcium chloride and malic acid to create a tea that was hot on one side of the glass and cold on the other (Blumenthal, 2009).

Methods and Techniques

Centrifugation

Centrifuges separate mixtures based on differences in density; a centrifuge spins tubes of equal weight around a central axis at high rates of speed, causing the heavier elements in the liquid to collect on the outer walls and bottom of the tubes, while the lighter particles remain separated at the top (Sanchez, 2016). When tomato juice was centrifuged, Blumenthal (2009) observed that it resulted in three distinct components, as illustrated in Figure 126.2.

Cryo-Techniques Using Dry Ice and Liquid Nitrogen

Dry ice (frozen carbon dioxide) and liquid nitrogen have been employed in kitchens in recent years, allowing rapid cooling at low temperatures (−78.5 °C and −196 °C, respectively), which prevents the formation of ice crystals. Blumenthal (2009)
highlights that dry ice is easier to buy and store than liquid nitrogen, and unlike liquid nitrogen, it doesn’t boil away. Instead, it sublimates, i.e., evaporates from a solid to a gas without ever becoming liquid. In the case of liquid nitrogen, it freezes instantly and can allow, e.g., fruit segments to shatter into individual pieces (Edelstein, 2018). Conventional freezing allows the development of large ice crystals, which damage frozen food, so more and more chefs are now using, for example, liquid nitrogen to form much smaller ice crystals in the making of ice cream and sorbet. Chefs are also using liquid nitrogen to create dramatic theatre when preparing dishes at the dining table; however, it is a dangerous ingredient and must be handled with great care, adhering to all safety precautions. The first chef to use liquid nitrogen was André Daguin, who in the late 1970s, astonished the New York food press when he demonstrated how to make instant ice cream using liquid nitrogen (Vintage Insatiable, 1998).

**Distillation**

Evaporating a liquid from a mixture and then condensing it into another space separates out solutions based on their physical properties. This can be done using a rotary evaporator, also known as a rotavap, which allows distilling under vacuum. The pressure inside the flask and condenser is lowered, which then lowers the boiling point of the solvent and other volatiles in the solution.

**Drying**

Sanchez (2016) notes that chefs have been increasingly inspired to utilize advanced equipment normally found in laboratories and industrial kitchens, and techniques such as vacuum-drying, spray-drying and freeze-drying/lyophilization. Dehydration has fast become a popular drying technique for use by chefs. The dehydrator shown in Figure 126.5a and b has a horizontal airflow that allows fast, even drying.

**Filtration**

Filtration allows solids to be strained from liquids, such as separating pulp from pressed juices and turning cloudy liquids clear (Potter, 2015). Techniques used by chefs include ice filtration and vacuum filtration. The former technique is clearly explained in a YouTube clip by Fotostudio Jan Bartelsman BV (2013), which shows François Guerds, from FG restaurant in Rotterdam, making a bouillon (thin stock solution). He blast chill and cools a stock solution, which following sieving, is placed in a muslin cloth. Then, he vacuum packs the cooled solution and places it horizontally in a blast freezer. The pack is removed, and the frozen sheet of stock is placed back in the muslin, which is placed in a perforated tray over a non-perforated tray. The whole lot is covered in clingfilm and defrosted. Blumenthal (2009) explains that as the stock melts, it trickles through a fine network of gelatine strands and drips into the tray. Any fat that is in the stock remains solid at fridge temperature and becomes entangled in the gelatine. In addition, the pure ice is also trapped, and the ice that contains salts, flavours and sugars melts because of the lower freezing point. The result is a clarified stock, which is more concentrated (because some ice is retained in the filter) and with the volatile aromas preserved. In vacuum filtration, a Büchner funnel is lined with very fine filter paper and attached to a vacuum flask, where the filtered liquid is collected. The pressure below the filter is reduced, thereby forcing liquid
Foaming
As early as 1987, Hervé This developed a recipe for a gelified foam, which he named ‘würtz’ in honour of Charles Adolphe Würtz, a famous chemist from Alsace (This, 2018). The method is as follows:

1. in a large bowl, put 5 g gelatine
2. add 200 g aqueous solution
3. add 100 g sugar
4. heat until the gelatine is dissolved
5. whip extensively while cooling (put the pan in a larger pan with cold water or ice) until a large volume of foam is obtained
6. store in the fridge for gelification of gelatine.

Stable foams are commonly used as garnishes on many dishes created in kitchens these days. The emulsifier lecithin may be used to stabilize mixtures that would generally separate without it. It is possible to create airs of sauces and soups, which can be served warm or cold. Other emulsifiers are used to integrate a watery medium into a fatty medium (Texturas, 2012). Another ingredient that is useful for creating a very light-textured stable foam is a sugar ester, which is derived from sucrose; this is used to prepare oil in water emulsions (Texturas, 2012) and is capable of foaming alcohols. Apart from emulsifiers, another ingredient in foam recipes includes xanthan gum, a thickener, which slows the rate at which foams collapse (Figure 126.6).

Gelling
There are many gelling agents that chefs are utilizing in kitchens today. These include low and high acyl gellan, agar-agar, kappa carrageenan, iota carrageenan and gelatine (Alicia Foundation, 2015; Blumenthal, 2009; Lersch, 2014; MSK, 2019). Gellan
allows a chef to create, for instance, heat-resistant jellies that can be served on hot dishes, change the textures and viscosity of liquids to create fluid gels, or turn fruit and vegetable juices into smooth stable purées that can be made into tuiles. Gellan also allows chefs to create flambe sorbets or ice creams. Agar-agar makes warm and cold jellies, and can be used in dishes with temperatures up to 85 °C. It is used as a binding agent in terrines and can also be used in siphons to make a stable mousse that can be served on hot dishes. Agar-agar also forms thermo-reversible gels.

Kappa carrageenan can be used as a vegetarian alternative to gelatine, and is ideal to use for encasing liquid centres while preventing separation. Iota carrageenan makes soft, elastic gels, which are freeze/thaw-stable and can be used as a glaze for semi-freddo and parfaits; it is best used in milk-based recipes, as it gels in the presence of calcium ions (Potter, 2015).

Sous Vide Cooking

One of the first techniques of molecular cooking was the implementation of the theory of temperature control when cooking, known as sous vide. This form of cooking allowed chefs to achieve results that were not possible with traditional cooking methods. Gisslen (2011) states that sous vide cooking in its simplest form has two steps:

1. Vacuum packing the item with seasoning or liquids in an appropriate plastic bag;
2. Cooking the item in the plastic bag at a constant low temperature in a water bath.

Chefs are now cooking meats at lower temperatures for longer. Garcia-Segovia et al. (2007) reported that texture is the parameter most affected when cooking meat over a long period of time. Extended cooking time causes collagen degradation and solubilization (Dikeman and Divine, 2014), leading to gelatine formation and a decrease in meat toughness while keeping juiciness. Using plastic bags in sous vide cooking allows the removal of air, which improves heating uniformity and avoids some unwanted flavour formation reactions that are oxygen-dependent (Myhrvold et al., 2011b).

Smoking

Smoking food involves cooking at lower temperatures for longer periods of time, while woods and coals are used as sources of smoke. There are two types of smoking: hot and cold. Hot smoking cooks the product, and cold smoking does not. For example, when fish is hot-smoked, it is cooked to a minimum of 62.8 °C for at least 30 minutes, while cold smoking requires the highest internal temperature to be below 35 °C (Rahman, 2007). Culinary smoking is a method used for imparting flavour rather than preserving, leading to companies creating innovative equipment and tools necessary for this purpose. These tools include upright electric smokers, water smokers (which incorporate moisture), wood boxes, cocktail smokers and smoke guns. The smoke gun has a small cage that holds wood shavings and is attached to a motor-operated fan, allowing the chef to smoke single servings of food products (Dunnam, 2017).

Spherification

Chefs are using both direct and reserve spherification to create jelly envelopes including liquids (see chapters on spherification). Sodium alginate and calcium are the main ingredients used in spherification, as the former is an extract of seaweed that reacts with calcium to form a gel. In direct spherification, a liquid may be coloured and/or flavoured and dropped into a calcium chloride or lactate bath using a syringe or caviar box. When the drop enters the calcium bath, the process of gelification (due to calcium-induced cross-linking of alginate molecules) begins, and small beads with a liquid centre are formed, which ‘pop’ in the mouth and release the trapped liquid. These are best served immediately, as they will continue to harden even after rinsing.
MolecularR (2019b) described the reverse spherification technique as dropping a liquid containing a mixture with calcium lactate gluconate or calcium lactate into a bath of sodium alginate. The gelation process is the same as direct spherification except that the calcium in the product moves outward (Vega, Ubbink and van der Linden, 2013). Reverse spherification is more versatile than basic spherification, as it can make spheres with almost any product. It is best for liquids with a high calcium or alcohol content, which makes it great for cocktails and dairy products like cheese, milk, cream and yoghurt. The resulting spheres are long-lasting and can be stored for later consumption. In contrast to direct spherification, the process of gelification can be stopped when the sphere is removed from the sodium alginate bath and rinsed with water. This also allows the chef to macerate the spheres overnight to add some extra flavour (e.g., in aromatized olive oil or truffle water).

As mentioned by Caporaso and Formisano (2016), there are challenges related to spherification, which include choosing the correct acidity and calcium concentration and the most appropriate solution density and concentration of flavouring agent.

### Conclusion

Even now, 16 years since the INICON project commenced, molecular cooking is less and less mistakenly referred to as molecular gastronomy. Despite this, a new style of cooking, molecular cuisine, was developed, which caught the imagination of the public across the globe. Initially, this type of cuisine was confined mainly to Michelin starred restaurants, but it has now become more mainstream. Elements of molecular cuisine such as foams, gels and emulsions can be found as part of a dish on many restaurant menus today. Restaurants are purchasing specialized ingredients and equipment so that they can use molecular cooking techniques to create dishes to tantalize the senses, allowing memorable and enjoyable dining experiences.


This H. 2013. Molecular gastronomy is a scientific discipline and note by note cuisine is the next culinary trend. *Flavour*, 2, 1. Available at: https://doi.org/10.1186/2044-7248-2-1.


