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Molecular Gastronomy – A Brief Look at Culinary Science in the 21st Century

Abstract

The role of food in our society has progressed far beyond mere sustenance. Food is now tantamount to culture and art. Leading the frontier in the culinary world is what some have termed 'Molecular Gastronomy'. This genre created an added dimension of food due to the application of physics and chemistry into the kitchen. There are three main practitioners of molecular gastronomy: by scientists in the laboratory, by professional chefs in restaurants and by amateur culinary enthusiasts at home. Therefore, molecular gastronomy finds a unique manner of manifestation by each party. It is conducted to achieve "culinary enlightenment" by the scientist, "culinary creativitiy" by the chef and "gastronomic education" by the homecook. Regardless of the venue and type of participant, this contributes to the culmination of science and art of our generation.

1. Introduction

Over the last two decades, the application of physics, physical chemistry and materials science in food science and technology has experienced rapid expansion. The role of food has evolved from a necessity to an indulgence. Both food scientists and chefs are bringing equipment and knowledge from the science laboratories into the kitchen, in an attempt to achieve culinary perfection. With this impetus, Oxford physicist Nicholas Kurti and French Institut National de la Recherche Agronomique (INRA) chemist Hervé This coined the term "molecular gastronomy"[4]. Molecular Gastronomy was a subdiscipline of food science that utilized physical and chemical to explain the transformations of ingredients during the cooking process. Today, this term is used to describe a modern genre of cooking that takes advantage of the technical innovations of science. Most importantly, the scientific approach to cooking not only helps improve the quality of the current products, it also opens up many new forms of culinary expression in the world of fine dining.

2. Techniques, Tools and Ingredients

A huge part of the appeal of molecular gastronomy is the intrigue it generates by employing an array of techniques, tools and ingredients that are not conventionally found in the kitchen. Some of these are:

a) Carbon dioxide source for adding bubbles and making foams.

b) Immersion blender for making foams.

c) Liquid nitrogen for flash freezing and shattering.

d) Thermal immersion circulator for sous-vide, as mentioned below.

e) Maltodextrin to turn high-fat liquid into a powder.

f) Hydrocolloids such as starch, gelatins, pectins and natural gums are used as a thickening, gelling or emulsifying agent to stabilize the structure of the food.

g) Transgutaminase is a protein binder used as meat glue.

h) Spherification is used to make liquids visually and texturally similar to caviar. Liquids are mixed with a small quantity of sodium alginate then dripped into a bowl filled with a cold solution of calcium chloride or calcium carbonate.

i) Ultrasound is used for higher precision with regard to cooking times

j) Sous-vide technique using a vacuum seal and hot water bath[5].

3. Sous-vide

One technique that has been exceptionally popular among many of today's top chefs is to Sous-vide their dishes[6,7]. This term is a French for the word "under-vacuum"[8]. The sous-vide method of cooking involves sealing the food in an airtight plastic bag before placing it in a hot water bath. The water is used to maintain an even temperature, typically around 55 to 60°C for meats, but cooked for a significantly longer time. The purpose of such a technique is to achieve more even cooking so as to ensure that the food remains juicy.

Even though this cooking technique has only risen in popularity recently, it was first proposed in 1799 by Sir Benjamin Thompson[9]. Subsequently, it was re-discovered by American and French engineers in the mid 1960s but was used as an industrial food preservation method. Subsequently, this technique was only properly brought into the kitchen in 1974 by chef Georges Pralus of Restaurant Troisgros in Roanna, France. Pralus discovered its usefulness when he was experimenting different methods of cooking foie gras and found that this was the most effective because the foie gras maintained its original appearance, fat content and texture[10]. Another notable pioneer of the sous-vide method was Bruno Goussault. He worked as the chief scientist of Cuisine Solutions, a Virginia-based food manufacturer. There, he researched how the geometry and chemical properties of different foods affected its cooking time and temperature parameters[10].

The procedure is relatively simple. First, the food is vacuum-sealed in a plastic bag. This prevents any losses of flavor or juices by the food to its surroundings. Next, the food is placed in a hot water bath and cooked for a long period of time. The complexity of this technique lies in the exact choice of temperature of the water bath as well as the cooking time. The hot water bath is set to a constant temperature as the desired final cooking temperature. This prevents overcooking because based on the laws of thermal equilibrium, the temperature of the food cannot exceed that of the water bath. With regard to how even the food is cooked, sous-vide helps achieve a very gradual temperature gradient along the thickness of the food because of the low rate of heat transfer. This is in comparison to grilling or frying where the surface of the food is exposed to much higher levels of heat and thus it has a significantly sharper temperature gradient and a less even cook. Thus the additional advantage of sous-vide is that it can also cook food of various sizes and shapes and still achieve a very even degree of completion.

The low, even temperature also has a significant impact on the succulence of the food. At these lower temperatures, the cell walls of the ingredients remain intact and do not burst[10]. With regard to cooking meat, the medium heat is sufficient to hydrolyze the tough collagen in the connective tissue into gelatin, while the meat's proteins do not denature to a degree when its texture toughens and moisture is wrung out of the meat. Sous-vide can also be used to cook vegetables thoroughly while maintaining a firm and crisp texture. The low heat ensures that the cell walls are mostly intact while the pectic polysaccharides are depolymerized. This allows for the gelatinization of starch in the vegetable without overcooking[11].

The bag is vacuum-sealed more for practical purpose than for culinary reasons. It is done to maintain consistency and to increase the food's preservation from the time it has been cooked until the time it is served. This is because prolonged exposure to air may result in various chemicals in the food oxidizing upon interaction with air. For example, the fat in meat will become rancid after prolonged exposure to air[11].

However, there are some limitations to this technique. Besides the impracticality of the extended cooking time, it also falls short in some aspects of taste. One critical reaction in the cooking of meat is known as the Maillard reaction. This is also known as the browning of foods. However, this can only be achieved once the food is exposed to high temperature. Due to the low temperature of the sous-vide, therefore browning will not occur[11].

4. The Maillard Reaction

The Maillard reaction was named after chemist Louis-Camille Maillard who first described it in 1912 while attempting to reproduce biological protein synthesis[1,2]. The reaction is a form of nonenzymatic browning due to a reaction between an amino acid and a reducing sugar in the presence of heat. This reaction is one that is highly pervasive amongst various foods and is responsible for the fundamental flavors and colors of steak, toasted bread, biscuits, French fries, roasted coffee etc.

The reaction begins when the carbonyl group of the sugar reacts with the amino group of the amino acid. This produces both N-substituted glycosylamine and water. The unstable glycosylamine then undergoes Amadori rearrangement to form ketosamines. Subsequently, three possible reactions occur. First, the ketosamines may break down into water and reductones. Second, diacetyl, aspirin, pyruvaldehyde and other short hydrolytic fission products may be formed. Third, the ketosamines can produce nitrogenous polymers and melanoidins[3].

For a biscuit-like flavor in baked goods (e.g. bread, popcorn, tortilla), the Maillard reaction produces 6-acetyl-2,3,4,5-tetrahydropyridine. In the roasting and searing of meat, the Maillard reaction breaks down the tetrapyrrole rings within the muscle protein myoglobin.

While the visual and taste results of the Maillard reaction are similar to that of carmelization, the two are vastly different. The Maillard reaction involves amino acids whereas carmelization is the pyrolysis of sugars.

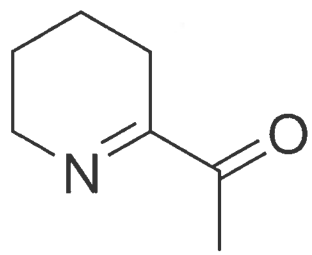

Figure 1 – 6-Acetyl-2,3,4,5-tetrahydropyridine is responsible for biscuits or cracker-like flavors

5. Conclusion

Advancements in chemical science have had extensive influence on cooking. In the constant pursuit for culinary perfection, scientists and chefs alike are enabled by the advancement of science to revolutionize the way that food is prepared. The question of "how" to cook has no evolved into "why" is it done in that certain way. For example, spectroscopy is used to understand which chemical triggers what flavor to our senses. This builds a lot of excitement for the next phase in the chemistry of food where foods can be constructed with the precision of that of the laboratories.

6. References

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