Introduction to molecular gastronomy and to its applications in science education

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Abstract This article looks at the history of molecular gastronomy, how it is defined and used in teaching natural sciences. The article also discusses the cooperative research and development project started in 2011, as well as an affiliated molecular gastronomy continuing training project for teachers. The project involves developing new research-based and meaningful approaches to teaching sciences, especially chemistry and home economics, in cooperation with teachers.

1. Food, mankind and science

Food has played a significant role in the development of human and mankind. When humans started to use fire to cook the food, the human biological system could process the food's nutrients more effectively. Various food poisonings could also be eliminated through cooking. In the Agricultural Revolution humans transitioned to a lifestyle of settlement, agriculture and cattle breeding. It also enabled humans to concentrate on the taste instead of just the sufficiency of food (Myhrvold et al., 2011).

Many scientific inventions have their origins in food inspired research. Some of the first written texts on food-related scientific studies were found in ancient Egypt. An anonymous person had studied why fermented meat weighs more than unfermented meat (Myhrvold et al., 2011). During the 1780s Antonio Lavoisier scientifically examined the density of meat stock (This et al., 2006). William Scheele discovered maleic acid in 1785 while studying apples (Doppins, 1931).

Food and nutrition sciences born in the early 20th century were mainly focused on nutritional or processing features of food and ignored the features related to its enjoyment. In the 1980s this was considered a deficiency, until in 1988 French Hervé This and a professor of physics in Harvard, originally Hungarian Nikolas Kurti, stated that cooking and gastronomy deserved to be considered a separate research subject in natural sciences (This, 2009).

2. Molecular gastronomy

2.1. History of molecular gastronomy

The scientific processes in cooking were first introduced to the public in 1969 when Nicholas Kurti held a televised presentation ”The Physicist in the Kitchen” for the Royal Society. In the presentation he explained the principles of microwave heating and demonstrated how pineapple juice tenderised pork (Lersch, 2012). In 1984 Harold McGee published his work *On Food and Cooking – The Science and Lore of the Kitchen*, where the chemistry and physics of home cooking were systematically introduced for the first time (McGee, 2011).

The historical origins of molecular gastronomy are not entirely beyond dispute (Cousins et al., 2010). The term molecular gastronomy was first used during the ERICE international scientific workshops. The first ERICE workshop was organised in 1992 by the initiative of Hervé This, Nicholas Kurti ja Elizabeth Cawdry-Thomas. The term *Molecular and physical gastronomy* was used initially, but Hervé This shortened it to *Molecular gastronomy* in 1998 after Kurti’s death (McGee, 2011).

Coming to the 21st century, many restaurants started to utilise scientific information and equipment to come up with new dishes. A new gastronomic movement was born that is often misleadingly referred to as molecular gastronomy. The term *molecular gastronomy* refers to a discipline where the purpose is to study chemical and physical phenomena, not a gastronomic orientation (Cousins et al., 2010).

2.2. Defining molecular gastronomy

Molecular gastronomy is the scientific study of food, cooking and enjoying food. It considers the chemical and physical phenomena in cooking and aims to explain changes that take place during the cooking process (This, 2009).

Molecular gastronomy entails three fields: technical, artistic and social. The technical field refers to the aim to explain the scientific phenomena and processes behind recipes. Enjoyment of the food does not come solely from a technically perfect performance; aesthetic (e.g. the setting) and social (e.g. the company) factors also have a significant effect. These phenomena are a part of molecular gastronomic research as well.

Molecular gastronomy aims to:

- Model culinary definitions
- Collect and test culinary precisions
- Explore scientifically the art component of cooking
- Scientifically explore the social link of cooking. (This, 2009)

Molecular gastronomy explores culinary definitions and contents of recipes. In addition to culinary definitions, recipes include so called culinary precisions that give detailed instructions for technically implementing the recipe (This, 2005). These include such suggestions as “whip the cream in cold water” or “sprinkle lemon juice on apple slices to keep them from turning black”. Kitchen stories can also be folk tales, proverbs or health and sanitary advices.

3. Molecular gastronomy and teaching of sciences

There are many challenges in teaching sciences. One significant challenge is to make the students understand the meaning of what they learn (Gilbert, 2006). Transfer of learning has been discovered to be poor. Problems can be solved in familiar contexts but not when transferred to a new environment (Osborne & Collins, 2000). The students have difficulties in finding meanings for individual facts. The students do not see how sciences are relevant and they do not understand why they should study them (Gilbert, 2006). Natural sciences are considered important but the students themselves are not interested in their study (e.g. Kärnä et al., 2012). One possible answer for the challenges in teaching sciences is contextual learning where scientific applications and everyday contexts form the basis for scientific concepts and ideas (Bennet et al., 2007).

Food- and cooking related phenomena offer a possibility to approach natural sciences based on the students’ everyday experiences. The aim of contextual learning is to raise the students’ interest towards learning sciences by using familiar contexts and helping them to understand the meaning of what they learn in their own life (Bennet et al., 2007). A number of studies show that adding a context increases the students’ interest towards learning and helps them to see the connection between natural sciences and everyday life (Bennet, 2005; Bennet et al., 2007). When the student is interested in what he is taught, the learning results are better (Ainley et al., 2002).

The possibilities that food and molecular gastronomy bring to science education have been noticed in many countries, for example in France, Great Britain and Netherlands (Barham et al., 2010; Linden et al., 2008). In Finland, chemistry education material has already been produced for the context of chemistry in kitchen (Makkonen & Aksela, 2006) and teachers have been given continuing training for it. The students feel that food, cooking and molecular gastronomy are possible contexts for interesting chemistry education (Västinsalo et al., 2010).

4. Possibilities of molecular gastronomy in school science education -project

A research and development project that studies the use of molecular gastronomy in the context of chemistry education and develops new approaches to teaching has been operational since 2010 in the Chemistry Teacher Education Unit of the University of Helsinki. Professor Maija Aksela acts as the director of the research group. Professor Anu Hopia from the University of Turku cooperates in the project.

Two Pro Gradu theses linked to the project have been completed: Tutkimuksellinen proteiinien opiskelu molekyyligastronomian kontekstissa (Vilhunen, 2012) and Argumentaation tukeminen yläasteen happamuuden kemian opetuksessa molekyyligastronomiaa soveltaen (Töyrylä, 2012). Several bachelor’s theses are also being written, as is one doctoral thesis. Research has been conducted partly in connection to the continuing training of molecular gastronomy in teaching.

4.1. Continuing training for molecular gastronomy in education

The three year continuing training project for chemistry and home economics teachers was started in the University of Helsinki in January 2011. The continuing training is a joint project between the Chemistry Teacher Education Unit of the University of Helsinki and Finland’s Science Education Centre LUMA.

The goal of the training is to find new approaches to chemistry education that inspire students and to promote cooperation between different subjects in schools. Another purpose is to produce new education material for teaching chemistry and home economics in the context of molecular gastronomy; material that takes advantage of modern teaching tools, including molecular modelling and measurement automation.

During the 18 months of being operational, 22 secondary school teachers from 11 schools around Finland have attended the training. Both the chemistry teacher and the home economics teacher from each school have participated. The implementation model has included 12 two-day meetings where the themes of national core curricula have been discussed together with experts (Vartiainen et al., 2011). In between the training meetings the teachers tested the received information with their students and reported their experiences.

The basis of the training is in so called kitchen stories (culinary precisions) whose scientific study is one of the aims of molecular gastronomy (This, 2009). Before the first meeting, the teachers taking part in the training collected precisions from their students. The teachers wrote reports of the gathered precisions, and these were used as the basis for the training themes. The kitchen stories utilised in the training, and for which education material was developed, included the following: “if you add salt to water it boils faster”, “molten chocolate is ruined if even a drop of water comes in contact with it”, “egg whites whip faster if you put lemon juice with them" and "even a small amount of yolk ruins an egg white foam".

Molecular gastronomy is utilised when new dishes and cooking methods are developed using scientific knowledge. In the continuing training, new methods developed with molecular gastronomy for making creamed food, sorbets and jellies were applied to teaching chemistry. Various chemical and physical processes involved in cooking were examined in the training and applied to school education. This resulted in new education materials focused on preparing chocolate confectionary, blueberry trio curd, layered drinks, beurre blanc sauce and caramel sauce. The new education materials deal with following key concepts in chemistry: solubility, proteins, carbohydrates, sourness, water features and emulsions.

The continuing training will continue until 2014. The final part of the training focuses on further developing the existing education material and producing new ideas.

5. Conclusions

The benefits of molecular gastronomy to society, food industry, scientists and research have been acknowledged. When the processes in cooking are better understood, choosing the right ingredients and methods to prepare traditional foods becomes easier, as does developing new dishes. The complexity and subtlety in the food and cooking processes give scientists an option to consider a wider area than just one reaction, molecule or a process. Food industry can apply the new information received through molecular gastronomy to produce quality food at an affordable price for the ecologically aware consumer (Linden et al., 2008).

Molecular gastronomy should be well suited for teaching sciences in school (Barham et al., 2010). The key concepts in core curriculum can be discussed through molecular gastronomy and it can also support meaningful and unifying teaching. According to our studies, students consider studying in the context of molecular gastronomy to be interesting (Västinsalo et al., 2010). Molecular gastronomy is also suitable as a theme of contextual learning in studying the key concepts in chemistry (Vartiainen et al., 2011).

When molecular gastronomy is used in teaching sciences, the goal is not simply to raise the students' interest towards it. The primary purpose is to include an element from the students' everyday life that enables individual and critical thinking. One aim is to provide tools for the future for those who do not see sciences as their future career: choices based on scientific knowledge, ability to search and apply information and the ability to argumentatively express one's views are all basic skills that can be acquired by anyone.

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