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Teaching Science to Chefs: the benefits, challenges and opportunities
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Abstract:
The science of cooking is being taught at a small handful of culinary schools across the globe, and there seems to be a general consensus that scientific understanding can be a valuable tool for an aspiring chef. There is however very little information available on how these scientific topics are being disseminated to chefs. In this communication, we will introduce and discuss two chef teaching environments where scientific topics are or have been taught: The Culinary Science Laboratory at Westminster Kingsway College in London and the Gastrolab at the University of Southern Denmark in Odense. Our conclusion is that the science of cooking is an important topic valuable for the education of the next generation of chefs, but there are challenges associated with teaching this academic subject in a vocational setting, and we feel that further research should be done to look into the methodology of teaching science in the kitchen, and that there is a need to develop a standardized syllabus for the delivery of this subject.

1 Introduction to the general practice of teaching science in chef schools:
People have been preparing food for several thousands of years, and the skills and knowledge associated with cooking, like so many other skills, have traditionally been passed on between mother or father and child. In the professional environment, the traditional pathway for an aspiring chef was through an apprenticeship, and in the last few hundred years or so, culinary schools have become a more common route for training. Culinary schools or chef schools provide

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a place for chefs to attain the basic knowledge of traditional food preparation methods and learn the skills required for their trade, but it also ensures that the education and training of chefs lives up to certain standards on a national level.

Traditionally, Food Science has not been taught in culinary schools - this discipline has always been one reserved to aspiring scientists (rather than chefs) as part of mainstream University degrees, often with a focus much more related to either human nutrition or food production. Since the introduction of Molecular Gastronomy as a scientific discipline in 1989 (Kurti and This, 1994), some Universities now offer modules and courses dedicated to this field of research, such as modules on the Bachelor and Masters degrees in the labs at the Dublin Institute of Technology in Ireland (Valverde et al, 2011), a Masters degree at the University of Copenhagen in Denmark (Risbo et al., 2013) or the General education science course, “Science and Cooking: From Haute Cuisine to the Science of Soft Matter” which is offered to undergraduate students at Harvard University (Rowat et al., 2014). Since these courses focus much more on the science of cooking, i.e. the part of the process that a chef can control, rather than understanding food production at the field or ingredient processing level (which is more a focus of Food Science), it has inevitably become of interest to try to introduce this sort of subject into chef education.

The teaching of the science of cooking in a culinary environment is a relatively new concept, and currently not very common in chef schools within the UK (although interestingly Food Science did used to be taught in some chef schools, however at the time it focused more on nutrition and food safety, rather than the science of flavour and cooking methods). In Denmark, there is a law stating that specific scientific topics are compulsory in chef schools, however there is no formal requirement for the chef teachers to be additionally trained in science. Interestingly, in France, all chef students who want to become professional cooking and pastry teachers in public schools or lycee hotelliers now have compulsory scientific training in the form of an educational module in Molecular gastronomy (This, 2011). We have examples of individuals teaching science to chef students in Singapore, Cuba, Canada, Hungary and Romania (various, personal communication). However, in the absence of a standardized approach and content matter for this subject, people who teach science to chefs tend to develop their own content, structure, and teaching methodology for the course depending on what they see as
most fit for the skills of the people that they are teaching. It seems that this is approached differently not only internationally, but also nationally.

In this article, we focus on the teaching of science to chefs that is done in two culinary environments – firstly at the Culinary Science Laboratory at Westminster Kingsway College in London, where Rachel Edwards-Stuart teaches culinary science to chef students as part of their diploma course. Secondly, at the Gastrolab at the University of Southern Denmark - a gastrophysical research lab with individual courses held in collaboration with a local chef school. We will introduce the type of environment in which the chef-students are taught. Then we will discuss and highlight our observations of the benefits, challenges and opportunities related to the specific teaching environment, and how we propose our findings could be used to improve the teaching of the science of cooking to chefs in a more general sense.

It is important to note, that the article is not based upon a scientific study but a continuation of a presentation given at the Gastro-Science-Chef symposium held at the University of Copenhagen June 13-14 2018.

1.1 Teaching science to chefs in the UK – example of a culinary lab in a chef school

In September 2013, Westminster Kingsway College, one of the leading catering colleges in London, opened a Science Laboratory within its Culinary Arts department, which focuses on teaching Culinary Science to the chef students across all year groups. To date this remains one of the only facilities in the UK within a chef school which is dedicated to the teaching of science to chefs, and was built following the growing interest that chefs were developing in science and the success of more scientifically minded chefs such as Heston Blumenthal. The laboratory is furnished with a number of specialist bit of equipment, often only found in the more advanced development kitchens around the world, such as a rotary evaporator, a centrifuge, a freeze dryer, a sonic homogenizer, a pacojet, a dehydrator, liquid nitrogen as well as a number of water baths.

In this facility, chef students are taught the basic principles of Culinary Science throughout the duration of their chef diploma. In the first year, when the students are commonly about 16 years of age,
culinary science classes are embedded in their practical cookery classes rather than separately in the lab, and are taught by chef lecturers rather than science lecturers. We do this because we tend to find that on leaving school, young aspiring chefs want to be in the kitchen, learning the profession they have chosen, and resent being put back in a classroom or lab environment to study a subject they thought they had given up! During these practical Culinary Science classes, students are taught about the scientific reasoning behind basic culinary preparations, for example the role of vinegar in poaching eggs; the basic principles of foams as illustrated by egg whites; the principles of mayonnaise; and freezing points and boiling points as illustrated by sugar syrups and making icecream. Unlike the approach usually carried out in this area of teaching, where lecturers try and focus on combining foods and cooking techniques based on a shared scientific phenomenon such as elasticity and gels, energy transfer or diffusion (the Food and Cooking course at Harvard is an example of this (Rowat et al., 2014), the approach we take at Westminster Kingsway College is to teach the science behind individual food or preparation methods separately, as experience has shown that chefs find it easier to consider scientific principles within simple ingredient groups and recipes, rather than by linking seemingly very different foods together by a shared physical or chemical concept.

As students progress into their second year, they continue to learn about emulsions and emulsifiers and mousses and moussing agents, but we also bring in more complex topics such as the structure of meat and how marinades work, and the effect of temperature on cooking meat. We also introduce and explain the benefits and limitations of controlled temperature or water bath cooking at this point, and students carry out practicals focused on advanced mousses and emulsions, as well as how to make certain dairy products including butter, paneer, and yoghurt.

As students progress into their third year, we start to teach them more “innovative” culinary techniques and ingredients that they may not currently be familiar with, such as new gelling and foaming agents. They also get the opportunity to carry out a mini scientific research project, which teaches them how to carry out experiments in a controlled way and how to focus on fair tests, which is important in preparing them for possible future careers in culinary research and development. The Culinary Science lab is also used to teach some of the science modules to part time and full time chef students enrolled on the Foundation degree in Culinary Arts, such as
1.2 Teaching science to chefs in Denmark – example from a gastrolab
A gastrolab was established in February 2015 at the University of Denmark in collaboration with Taste for Life, a national center for research and communication of topics concerning taste to researchers, practitioners and the public. The purpose of the gastrolab was to facilitate research and teaching in the area of the science of cooking, which in this setting was termed gastrophysics – the physics of gastronomy (Risbo et al., 2013). Until the end in 2018, the gastrolab held 1 or 2 day courses for pupils and students at highschools, colleges and university level, and visiting chef students from the local culinary school. In the context of this article and in relation to teaching chef students, the purpose of placing the Gastrolab at a university allowed researchers within the field of gastrophysics to disseminate the most recent knowledge concerning taste and gastronomy directly to chef students, while also having access to state-of-the-art microscopy (Christensen et al., 2015) and chemical analysis methods as teaching tools. During the 1-2 day course, the chef students were given a short lecture (1/2 hour-1 hour) from the research scientists based in the Gastrolab on some of the newest knowledge and research in the field, and the students then had to investigate a chosen culinary problem or observation and use the available analytical tools to investigate this problem rather than just using their senses, which is the only “analytical tool” that they normally have access to in their kitchens. To be able to see cause and effect when carrying out their experiments or analyzing samples, the students were introduced to scientific methodology applied in a culinary context (Christensen et al., 2017). More specifically, the students had to come up with a hypothesis based upon their problem or observation, where they had to consider fixed and variable parameters carefully. They then had to design an experimental setup, which would proposedly allow them to see a clear causal effect, and finally they had to test their hypothesis in the gastrolab setting and evaluate the outcome using both the available analytical tools such as a microscope and a texture analyzer, combined with using their senses to measure flavour. The invited students were at the end of their culinary education program, so mostly last year students. The course ran over 1-2 days
and was made compulsory to participate for the classes, but the course was in itself not part of their formal education program.

2 Teaching benefits and challenges
2.1 Food composition and structure – interactions of basic food molecules
When teaching chef students about the composition of ingredients and the physico-chemical properties which change during preparation, almost everyone we encounter seem to be in consensus that the more knowledge the chef-students can acquire in basic food science or culinary science, the more they will understand why you take certain steps in food preparation, and the more likely they are to follow certain culinary precisions, e.g. adding vinegar when poaching eggs or adding sugar after whipping the foam when making meringues. Many problems encountered during day to day activities in the kitchen have a root in some basic molecular interaction of either water, protein, carbohydrates or lipids, under the influence of salts, pH, temperature and response to mechanical interaction (e.g. kneading, whipping etc.) and having some level of scientific insight can help chefs troubleshoot when they encounter problems. We have observed, however, that chefs and culinary students sometimes struggle in understanding some basic physico-chemical properties or concepts, especially ones which challenge words they may use frequently in the kitchen, such as the difference between pH and acidity, the difference between temperature and heat, and between flavor and taste. (In Denmark for instance, there is no specific word for flavor, but the word taste or “smag” is used interchangeably, which makes it even more confusing.)

In addition to the obvious benefits, there are a number of limitations in teaching chefs about the composition and structure of food – culinary students can sometimes have a lack of interest in science, they see it as boring. It is therefore interesting to note that where the science of cooking is introduced as a way to engage academic students in the area of science, such as at Harvard University, the subject is seen as "sexy" or fun. We attribute this to the public’s general view that most people enjoy food and cooking and choose to indulge in this in their spare time, yet this is not the case for science, where people who love science tend to do it as a professional rather than a hobby. Furthermore, cooking is often perceived by students as linked to a “natural” and “pure” way of preparing food, and they often see science as going against this since many people associate “scientific cooking” with the use of gelling agents and foaming agents, all of which have E-numbers, or in general relate it to commercial or
mass food production. Indeed Caporaso and Formisano (2016) explain that in their experience, it seems that the general public, chefs and scientists are divided when it comes to their views on Molecular Gastronomy (MG). “One group is enthusiastic, very active in the diffusion of knowledge, concepts and applications of MG. The other group consists of people who criticize the “chemicals in the plate”, considering them harmful, regarding MG as an attack to the traditional gastronomy of their country, or just a fancy application of new techniques to create uncommon dishes” (Caporaso and Formisano, 2016).

2.2 Adopting scientific methods in the kitchen

In terms of development and innovation in the kitchen, having knowledge of the basic structures of food ingredients and how they interact with other ingredients is instrumental when developing new creations, as is understanding how to adopt a more focused and scientific way of testing rather than using trial and error. Robust R&D in the kitchen can be carried out by understanding how to carry out scientific experiments (such as understanding the concepts of a fair test, changing aims, and changing the right parameters). It is recognized generally in the elementary school system that an inquiry-based approach to science education is a sensible way to engage in conceptual scientific learning to students (Minner et al., 2010). In this perspective we think that by teaching chef students the fundamentals of culinary science, molecular gastronomy or gastrophysics, as well as an inquiry-based methodology, will enable them to tackle scientific problems related to development of new dishes in the professional kitchen. We do not think this way of acquiring knowledge should be seen as replacing any other standard method of chef training, but rather be part of the “toolbox” of the modern chef.

We acknowledge that there often is a lack of time and resources in a regular functioning kitchen for chefs to really focus on development, so they can sometimes see scientific research as unrealistic. But here it is important to distinguish between actual research to discover new phenomena, which can take time and money, and working methodically when trying to improve a dish or solve a problem instead of changing several parameters simultaneously, which does not require time and money, and if anything can save on both in the long term.
2.3 An understanding of flavour and sensory science

In our opinion, it is important that chef-students understand the mechanisms behind flavour and taste, since this helps to create dishes that really deliver in these aspects. Indeed, flavour perception is one area of food science that has really captivated the interest of chefs in recent years and chefs such as Heston Blumenthal have been using research in this field to create unique and memorable dining experiences for their customers (Edwards-Stuart, 2012). It is not only important that chefs are able to detect specific aspects of taste and aroma in a dish, but also that they are able to describe flavour in an objective way so that they are able to communicate more effectively with their team. Introducing the basic concept of sensory science and methodology to chefs can be of benefit to culinary R&D, however we are well aware that the time taken to design and carry out sensory testing in a scientific way, as well as the statistical knowledge required to interpret the results, can be completely impractical in a kitchen environment.

3 Opportunities and future:

We believe that sometimes using the kitchen “as a lab” is one way to make the students understand that science is something which also happens outside a normal laboratory. Ensuring that experiments in a culinary science course not only introduce advanced additives and new methods, but also tackles scientific perspectives on everyday problems, is one way of showing the viability of a scientific view on the cooking process.

One important observation from Westminster Kingsway College is that access to advanced equipment such as rotary evaporators, centrifuges, freeze dryers, sonic homogenizers, or water baths can be used to experiment with different techniques but they cannot be used for the proper analysis of food ingredients and preparations. If the Culinary Lab was situated within a university or research centre, although it would be less convenient for the students who would have to travel there, it would have the benefit of being able to access more analytical equipment that would make it possible to carry out true analytical research in this field. Conversely, as observed at the Gastrolab in Denmark, having an access to analytical instruments without being an integral part of a chef program means that some of the larger and more specialist kitchen equipment, which may be required for testing, may not be available, and some interesting and
relevant culinary observations worth investigating might be missed. Encouraging closer collaborations between universities and culinary colleges worldwide would definitely help address these challenges where topics such as culinary science or a gastro lab is not available.

3.1 Culinary science as a topic
Despite it not being a discipline that is currently accredited everywhere in the world, as mentioned in the introduction many places around the world are teaching science to chefs. However, as we have briefly discussed, there is very little alignment in terms of content and teaching methods, both on the international and national level. Individuals at each institution tend to teach what they feel is most suitable to their institution and their learner needs. One challenge has been the availability of literature and textbooks on the subject of culinary science for the student group, which is scarce. Harold McGee’s on Food and Cooking remains maybe the most comprehensive literature, but this book is not specifically aimed at chefs. Furthermore, the most recent and up to date scientific research in this field is usually published in scientific journals rather than books, and these can often be difficult for chefs to access and comprehend.

In terms of terminology, there is a potential need for some alignment and standardization across the field in terms of universal content matter, and how this in some way can be made more official. Even the name differs across the globe – many use the term Molecular Gastronomy when describing the teaching of science to chefs, a term which, from its emergence in 1989, has been pivotal to making people aware of the importance of science in cooking, yet many individuals and institutions are moving away from the term Molecular Gastronomy (The guardian, 2006), often due to its associations with the use of additives in cooking, favouring instead names such as Culinary Science or Gastrophysics. Due to the number of different names that exist for this specific subject area, it is even harder to come up with a simplified definition of the subject matter and the content which it should cover, and this is an area which in our opinion should be considered for further study in the future.

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