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Review of Physics in the kitchen by George Vekinis

Megan J Povey

University of Leeds , March 2024

Brewing tea is a great example of a diffusion process but there is more to making tea than diffusion. At a glance at my morning cup of black tea revealeds a cloudy layer at the bottom of the cup. This is 'Tea Cream' arising from the formation of nanoclusters of theaflavin in combination with caffeine and calcium (Jöbstl E, Fairclough JP, Davies AP, Williamson MP. Creaming in black tea. J Agric Food Chem. 2005 Oct 5;53(20):7997-8002. doi: 10.1021/jf0506479. PMID: 16190662.)

ThisWhilst tea cream is not mentioned, brewing tea is one of the many examples covered in "Physics in the Kitchen" by George Vekenis, Director of Research at the National Research Centre "Demokritos" (NCSRD) in Greece. In writing this book, Vekinis joins a long tradition of physicists writing about cooking; . This is a Cook's book (Not a cookery book). Its audience is anyone interested in cooking and

is full of insights into the physical processes underlying the creative processes in a kitchen, for example making sauces, preparation of vegetables, the use of wines, vinegars and lemon and the physics underlying conventional and microwave ovens… It is part of a long tradition of Physicists writing about cooking; from Nicholas and Giani Kurti (1988 "The crackling is superb"), Peter Barham (*The Science of Cooking* (ISBN 3-540-67466-7) and Hervé This, (2003. "Molecular gastronomy." Sciences des Aliments 23(2): 187-198). It is a shame that Vekinis' predecessors are not mentioned. Caesar Vega and Jan Ubbink (2008. "Molecular gastronomy: a food fad or science supporting innovative cuisine?" Trends in Food Science and Technology 19(7): 372-382.) make a distinction between molecular gastronomy and science-based cooking, the first relates to the scientific understanding of cooking and eating processes and the latter refers to the application of science principles and tools for the development of new dishes, in the context of haute cuisine.

The book is full of insights into the physical processes underlying the creative processes in a kitchen, from making sauces and the preparation of vegetables, the use of acid and the physics underlying conventional and microwave oven.

I shared the book with some teacher friends of mine, who all enjoyed it – I was told that it would form part of their school food science teaching. They liked the logical structure and the way that it progresses from simple to more complicated. For example, the second chapter straightforwardly describes the relationship between heat and energy and then goes on to explain more complex thermodynamic concepts.

My partner, who also read the book, skipped straight to the section about vinegar and recommended it – one of the book's strengths is that whilst it has a logical structure, it is possible to dip in and out without reading everything. It would make a good resource for undergraduates studying soft matter/food science.

My teacher friends were enthusiastic when I shared the book with them. They liked the structure and that it was possible to dip in and out without reading everything. My partner skipped to the bit about vinegar and immediately recommended it. Another liked the fact that it is well organised, the logical structure and the way it progressed from simple to more complicated and was impressed with the section on vegetables. The School teaches food science at GCSE and I

Commented [KS1]: I moved this up because I really like this and think it makes an eye-catching first paragraph

Commented [MP2R1]: I've kept this

Commented [KS3]: This sounds as if tea cream is mentioned in the book, but as far as I can tell it isn't. Is this correct? If so, this should have a different example, I had a quick look and he also has a discussion of the chemical changes that make tea bitter, which sounded interesting.

Commented [MP4R3]: He uses tea infusion as an example of diffusion but doesn't mention tea cream, which makes an important contribution to flavour and requires a minute or so to develop. The tea cream should then be mixed with the rest of the tea through the addition of hot water.

Commented [MP5R3]: How about this rephrasing?

Commented [KS6]: Can you give an example of the simple and more complex topics? I saw that there is an introduction section at the start that covers thermodynamics etc

Commented [MP7R6]: How about this?

Commented [KS8]: Do you think the book would make a good resource for undergraduates studying soft matter/food science?

Commented [MP9R8]: Yes

Commented [KS10]: Is this the part about enzymes?

~~was told that it would definitely form part of their teaching. Everyone who read it enjoyed it and found it stimulating.~~

I particularly enjoyed the section about sauces. All my experience in this area involves the preparation of a roux, where starch such as flour is heated in a fat like butter and a liquid such as milk. The fat gelatinizes the starch allowing it to absorb liquid and thicken the sauce.

~~There is a great section on the preparation of sauces simply by heating meat and fish in the presence of wine, vinegar and lemon, all my sauce preparation involves the production of a roux (starch combined with melted butter, herbs and salt and pepper then hot milk added to swell the starch so that the particle-particle contacts dominate viscosity); so~~ Iit was however a revelation to ~~realise~~ realize that sauces prepared in the "Greek way" ~~didn't~~ don't involve starch at all, just the heating of meat in the presence of an acid such as wine, vinegar or lemon. Vekenis explains that t~~T~~his~~e~~ ancient method of sauce preparation revealed in a large section on 'Creamy emulsion or Curdled Mess?' ~~in the book~~ involves the extraction of small molecules. However, as a food physicist, I did have some issues with the science in this and later sections.

In 'Edible ... Plastics – The Building Blocks of Life and Food' and 'More edible plastics – jellies, Sauces, Syrups and Creams', Vekenis draws a parallel between polymer science and food that I found unhelpful. Polymer science approaches do not adequately explain protein oligomerization and denaturation. The author does not mention that water-soluble proteins such as glycine and storage proteins such as serum albumin change their three-dimensional structure due to changes in the solvent properties of water in addition to the effect of heat. In the section on Wine, Vinegar, and Lemon we are told that "the preparation of a smooth sauce requires ... boiling of an acidic agent as a catalyst for a polymerisation reaction" and that "... Dry wine does the job too". But what is described here is not a catalytic reaction. For example, alcohol has a profound effect on the solvent properties of proteins which exist in a dynamic and complex equilibrium with water, also affected by pH (alkalinity and acidity) and metal and salt ions. In many instances, these effects are reversible, although by no means always, for example the denaturation of egg white protein during boiling is clearly an irreversible process! So, trial and error is still a big part of cooking and recipes are for that reason important.

~~and water solublewater-soluble proteins such as glycine and storage proteins such as serum albumin through changes in their tertiary three-dimensional structure due to the breakdown of the sulfhydryl bonds and their subsequent reformation into the denatured proteins which created the gel structure of the sauce.~~

~~Is~~*Physics in a kitchen* is not a cookbook, but I did find myself wishing that Vekenis – who describes himself as a keen cook as well as a scientist, had included some recipes from his kitchen. I for one have benefited from learning how to make healthy sauces without starch and I feel that this would have greatly improved it.

~~However, as a food scientist, I did have some issues with the science as presented in the book, and I I struggled with the idea that 'polymerisation' underpinned the creation of sauces and found the presentation of Food Chemistry naïve.~~

~~In sections titles "Edible ... Plastics – The Building Blocks of Life and Food" and "More edible plastics – jellies, Sauces, Syrups and Creams", Vekenis draws a parallel between polymer science and food that I found unhelpful.~~

Commented [KS11]: What did you think of the large section on sauces on page 89? The discussion of flourless sauces that you describe here seems to build on Vekenis's discussion of emulsion in the previous section.

Commented [MP12R11]: Is the rearranged text better?

Commented [KS13]: Is this connected to the statement about catalysts in the previous paragraph?

Commented [MP14R13]: Is the rearranged text better?

Commented [KS15]: What did you think of the large section on sauces on page 89? The discussion of flourless sauces that you describe here seems to build on Vekenis's discussion of emulsion in the previous section.

Commented [MP16R15]: I loved it.

Commented [KS17]: Is Glycine and serum albumin mentioned in the book? I found this sentence interesting but the explanation I found in the book just said that the seafood "reacts" with the acid, which seemed a bit brief by comparison!

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Commented [KS18]: Added this because it's in the introduction

Commented [MP19R18]: Good

Whilst the sections themselves were illuminating, I found the parallels drawn with polymer science through sub-headings such as "Edible … Plastics – The Building Blocks of Life and Food" and "More edible plastics – jellies, Sauces, Syrups and Creams" unhelpful. Polymer science approaches do not adequately explain protein oligomerisation oligomerization and denaturation.

In additionFor example, in the section on Wine, Vinegar, and Lemon we are told that "the preparation of a smooth sauce sauce requires … boiling of an acidic agent as a catalyst for a polymerisation reaction" and that "… Dry wine does the job too". I have no argument with the stated practical outcomesVekenis is correct that acids produce smooth sauces. However, it is important to understand that what is described here is not a catalytic reaction.

Alcohol has a profound effect on the solvent properties of water and proteins exist in a dynamic and complex equilibrium with water which is also affected by pH (alkalinity and acidity) and metal and salt ions. In many instances, these effects are reversible, although by no means always, for example the denaturation of egg white protein during boiling is clearly an irreversible process!. So trial and error is still a big part of cooking and recipes are for that reason important.

What a shame then that the author has not included any recipes from his kitchen. This would have greatly improved it and I for one have benefited from learning how to make healthy sauces without starch!

Brewing tea is a great example of a diffusion process but there is more to making tea than diffusion and a glance at my morning cup of black tea revealed a cloudy layer at the bottom of the cup. This is 'Tea Cream' arising from the formation of nanoclusters of theaflavin in combination with caffeine and calcium (Jöbstl E, Fairclough JP, Davies AP, Williamson MP. Creaming in black tea. J Agric Food Chem. 2005 Oct 5;53(20):7997-8002. doi: 10.1021/jf0506479. PMID: 16190662.)

Commented [KS20]: Can you explain why this is?

Commented [KS21]: Can you explain why this isn't a catalytic reaction?

Commented [KS22]: Is this connected to the statement about catalysts in the previous paragraph?

Figure 1 Tea cream forming at the bottom of a cup of tea (Pic courtesy M. Povey)

Towards the end of the book, Vekinis looks at the physics behind kitchen appliances from microwaves to fridges. For example, the coupling between the electromagnetic field and polar water molecules is explained. Myths about the 'dangers' of microwaves and the non-use of metal objects are interestingly addressed. The effects of the non-uniform distribution of the electromagnetic field and the important role of water in microwave heating are mentioned. More could have been said in the section on microwave ovens regarding aboutthe idea that the heating effect of microwaves within the food is uniform. There is also a relationship between the wavelength of electromagnetic waves in the oven and the much shorter wavelength found in the food which is a function of water content. As a result, the food can focuses the electromagnetic field resulting in highly non-uniform heating which is a function of shape.. In fact, it is far from uniform so which is why it is important to 'rest' the food before eating, this allowings the thermal energy to diffuse and even out the 'hot spots'. There is also a relationship between the wavelength of electromagnetic waves in the oven and the much shorter wavelength found in the food which is a function of water content. As a result, the food can focus the electromagnetic field resulting in highly non-uniform heating which is a function of shape. Don't try baking a large potato in your microwave oven. You'll find the centre roasting and the outer cold! On the other hand, objects much smaller than the wavelength in the oven will heat uniformly which is why microwaving is a good way of thawing frozen peas. By the way, iceIce interacts much less strongly with the microwave field than water. Fill two egg cups with water and freeze one. First place the water containing cup into the microwave and within 30 seconds it will boil. Place the cup containing ice into the microwave and it will take much longer just to melt.

TThis is a great book. There is so much going on in the kitchen and understanding the physics enhances the enjoyment and enables the production of wonderful meals. Well done George Vekinis.

Commented [KS23]: This is interesting, but it also needs a few sentences commenting on what is covered in the microwave section in the book, and what you thought of it (aside from the omission you mention).

Commented [MP24R23]: Better?