

## Which knowledge is needed for « Note by Note Cuisine » ? Hervé This

Being an advocate, after, Louis Pasteur, Antoine-Laurent de Lavoisier and many others, of the difference between science and technologie, fighting, then, against the frequent confusion between the science of chemistry, on one hand, and the « chemical arts » which are pharmacy, cosmetics, perfumery, etc. I am also convinced that we lack chemistry. I am not saying that there are no relationship between science and technologie (it would be silly), and I don't see science as something more important than technology, but only something different, with links that we should clarify. Of course, some technical innovation can (should?) be derived from new knowledge produced by chemistry (science), but cannot we also consider that some (chemical) science can (should?) be made from questions coming from technique and technology? I don't consider that this science would be an « applied science », or a science for engineers (an oxymoron), but this is another story.

Here I propose to consider a remarkable example, as it is in between science, technology, technique, art, education... It is the issue of « note by note cuisine ». A particular application of sciences, but with consequences which justify that science makes new explorations!

### After Molecular Cuisine, Note by Note Cuisine

Let us begin rapidly with some needed definitions, as I know too well that there is a confusion between cuisine and gastronomy. I shall be very fast however, as I am giving much more details in many other texts.

Molecular gastronomy, first, is a particular branch of physical chemistry, where we look for the mechanisms of phenomena occurring during culinary transformations. Indeed, at the limit, this discipline is not really interested in cuisine, and only looks for new phenomena, new mechanisms, starting from cuisine.

Molecular cuisine, on the other hand, is cuisine. More precisely, it is a culinary trend whose definition is: cooking with new tools, new methods, new ingredients. By « new », we mean what was not in Paul Bocuse's cuisine, in the 1980's. And in 1984, I proposed to transfer all

chemistry laboratory tools, hardware, from labs to kitchens: vacuum evaporation devices, ultrasonic probes, liquid nitrogen, decanting bulbs, fritted glass filters, etc.

The culinary trend named molecular cuisine is now present worldwide, and there is no day without some Google alert on it. Each day, chefs are proposing new « molecular cuisine » menus, dishes... We can be happy of this technical improvement of culinary techniques... and remember that it was indeed the purpose of the proposal that we made at the very beginning of the 1980's, with a handful of friends (primarily Nicholas Kurti and I).

We can also observe that molecular cuisine is an application of science to technique. And we should add immediately that we have to hope that molecular cuisine will die soon (not molecular gastronomy!) because it will mean that the technical renovation of cooking is done.

Note by note cuisine, now? I proposed it indeed in an article that I published in 1994 in *Scientific American*, coauthoring with my old friend Nicholas Kurti. In the presentation of molecular gastronomy that was the topic of the article, I found it provocative to add the following paragraph, as a conclusion that Nicholas accepted:

« The manufacturers of wines and spirits are typically forbidden by law to improve the taste of their products by adding sugar or other chemicals. Nevertheless, if the consumer wants to use the results of chemical research to enhance the qualities of inferior wines or spirits, should he or she not be encouraged to do so? A few drops of vanilla extract may wonderfully enrich the flavor of a bottle of cheap whiskey. This kind of experiment can be extended to a large number of beverages and dishes. Perhaps in the cookbooks of the future, recipes will include such directions as « add to your bouillon two drops of a 0.001 percent solution of benzylmercaptan in pure alcohol. »

Kurti accepted this paragraph from me, but I can assure that both of us considered then my proposal as an extraordinary audacious. « Chemicals » in the kitchen! In food!

Today I would obviously not write the same text, first because I showed elsewhere that the word « chemicals » is wrong: a compound is a

compound, and it can be either extracted from plant or animal tissues, or synthesized, but it becomes chemical only if it is studied or used by a chemist, i.e. a scientist, for scientific purpose. For example, water is not a « chemical », except when it is studied in a chemistry lab, not when it is drunk !

On the other hand, « playing » with compounds can be more than just play: yes, some drops of a vanillin solution (synthetic, or from natural origin it does not matter, because the various molecules are entirely the same, with the same organoleptic properties) will give some mouthfeel to young brandies, for reasons that are unknown to my knowledge. This proposal, we have to say it, are based on the fact that, during alcohol aging, wood lignin which reacts with ethanol (the alcohol from wine and brandies) after a long chain of reactions, such compounds as syringaldehyde, or sinapic or vanillic aldehydes are produced. It is then « obvious » for a brandy lover to make such additions, when he or she has not enough money to pay for very old products. Finally, I think that even if benzylmercaptan is a good choice physiologically (in solution, at low concentrations, it has notes of onion, garlic, horseradish, mint, coffee), it can make many colleagues afraid, because they think (it is wrong) that mercaptans are... sulfurous compounds.

Anyway in 1999, I considered that the proposal to add compounds to food was only the beginning of the story: why not « constitute » dishes entirely compound by compound? This is « note by note cuisine ».

The principle of this new cuisine is the same as for synthesizers in music, with which one can produce any sound. In cuisine, the choice and particular use of well chosen compounds can make any possible food. Of course, all aspects have to be selected, as general organization of parts, particular shape, color, brilliancy, odor or taste of the various parts.

One could think that note by note dishes would be more difficult to make than just cooking plant or animal tissues, but the same remark was done for music three or four decades ago for music (it was said that it would be very difficult, let not say impossible, to build the notes wave by wave) and did not prevent the fast development of synthesizer music, because modern composers and musicians succeeded in making their own, new, shortcuts. Yes, building dishes note by note when one works from pure compounds, but why not using the same ways as for music? Who not use mixtures of compounds,

such as for music with waves? After all perfumes are already this, such as the various extracts of the flavouring industry.

## Questions

People are generally afraid of not by note cuisine. And nutrition : are we going to get all our nutrients, oligo-elements, vitamins? And toxicity: aren't these compounds dangerous? And consistency: don't you fear that it will be only liquid ? And farming and agriculture : are they going to die ? All arguments are good to justify that we keep our « traditional food », made of cassoulets, stews, choucroute... For all these food, nutritional « properties » are given with a lot of bad faith... because we « love » them. Even some of us justify eating chocolate because it contains potassium... but only some milligrammes compared to half of chocolate made of fat, and half of chocolate made of sucrose! We ask for an absence of toxicity... whereas at the same time we love meat cooked with a bbq, where the content in benzopyrens is 2000 more than it is accepted in smoked products of the food industry (remember that benzopyrens are very toxic).

Our « food neophobia » lead us to assume that the food that we learned to eat is « good », and to fear new food. And our human brain, instead of making us reject novel food as non human primates would do, leads us to negate new dishes and to legitimate old ones, even when the « virtues » of the old stuff are not demonstrated, the worst justification being that these food are safe because they are old (bad argument: smoked products were appreciated, but epidemiologists see clearly their danger today, through the high incidence of cancers of the digestive tractus, in populations of the North of Europe, who consume a lot of smoked products.

However our bad faith based on food neophobia is not a reason for not considering the interest of note by note cuisine. Why should we drop traditional cuisine, and adopt note by note cuisine? Indeed the alternative is not compulsory; as for molecular cuisine, we could keep traditional cuisine and add note by note cuisine. Or produce hybrids...

## The technical issue

The first question to ask, here, is to know the nature of compounds that we shall use. The culinary world is already very pure compounds, such as water, sodium chloride, sucrose,

gelatine... The public often ignores that these compounds were prepared by the industry, through various extraction processes, purifications, various technological modifications (for example, anti-aggregation compounds are added to sucrose)... Many other compounds could be prepared in the same way, such as saccharides, amino acids, glycerides... in particular because the food industry already prepares them, for formulation. For example, the industry of food additives produces pigments, vitamins, preservative agents, gelling or thickening... Certainly additives are not regulated as food ingredients, but could not they be in the future ?

On the other hand, the question of purity of compounds invites to make the same as for music, that is to say to enlarge the list of usable compounds with simple mixtures, what the industry already makes from products based on the cracking of milk or grain. Gelatine, for example, is not pure, in the meaning as being made of molecules of only one kind, because there is a strong molecular weight dispersion of the polypeptidic chains, due to the particular extraction performed to make it. Also starch is not pure, as it is made of two main compounds, which are amylose and amylopectin (we should say « amyloses », and « amylopectines », because here again there is no homogeneity). In passing, let us not forget that as starch comes in this way in the list of compounds that one can use for note by note cuisine, most techniques of pastry can be used for making note by note cuisine.

Let us come back to the question of « cracking » plant or animal tissues, which is indeed preparing fractions. From grain, the industry extracts polysaccharides, proteins, amino acids, surfactants... From milk, the industry recovers amino acids, peptides, proteins, glycerides... Could not we do the same from plant or animal tissues ? Could not we, using the same kind of processes, such as reverse osmosis, vacuum distillation, etc. prepare quite « pure » fractions, in order to do note by note cuisine ?

Many technology groups study this questions, and colleagues at the Montpellier INRA Centre, for example, devised a technique based on reverse osmosis in order to recover the total phenolics fraction from grape juice. We can add at this point that this fraction is very different depending on the raw material, grape juice from Syrah, or from Grenache, or Pinot, for example : the diversity of the initial products is not erased by the

fractionation process, so that cooks should be happy to play with the « terroir ».

The issue of « ingredients » having been discussed, we now have to consider assembling them into dishes. Now we should not forget that today's food are material systems of colloidal nature, with often a large proportion of water in them. Many organic compounds are poorly soluble in water, and emulsification is obviously a very important process in note by note cuisine. It is not the only one ; all dispersion techniques will be useful.

During this assembly, the various biological properties of food will have to be considered : of course, the nutritional content is important, but it would be a mistake to forget that food has to stimulate the various sensory receptors : vision, odor, taste, trigeminal system, temperature... Many questions are open now. For example, as we know how to determine the light absorption spectrum of a mixture of compounds in a mixture, if we know the individual absorption spectrum of each compound, we cannot predict the « color » of the mixture. Also, when one mixes odorant compounds in proportions near the perception threshold, unpredictable odors are obtained. Worst, the mixture of only two odorant compounds is not a solved issue : do they make a « chord » or a fusion ?

For tastes, the question is even more serious, because we ignore their receptors and their substrates, and it was discovered recently (less than ten years ago) that the tongue also include receptors for fatty acids with long unsaturated chain. This means that other important discoveries can be made ! In the meantime, one can use citric, malic, tartaric, acetic, ascorbic, or lactic acids... Or saccharides such as glucose, fructose, lactose, etc. and not only the old sucrose.

For trigeminal effects, some « fresh » or « pungent » compounds are known, such as eugenol (in cloves), menthol (one of its enantiomers only), capsaicin (for chilli), piperin (for pepper), ethanol, sodium bicarbonate... and many others.

From the consistency point of view, again technological work can be done, because making colloidal materials remains not studied enough. Making simple emulsions is sometimes considered difficult, but more generally one should not consider that texturization of formulated products is a solved issue, even if we now have surimis and analogous systems. Who will succeed making the consistency of a green apple ? Or a

pear ? Of a strawberry ? Non only the question of laboratory prototypes is not solved, but also the question of mass production is not considered (and this is why fruit companies providing products for the yogurt industry are so upset).

As a whole, much remains to be done, a lot of questions have to be studied by science and by technology. Let us finish this paragraph with an important observation : it would be uninteresting to « reproduce » already existing food ingredients. As synthetizers can make sounds of piano or violin, note by note cuisine could obviously reproduce wines, carrots, meats... but why ? Except for astronauts travelling during a long time, it is probably useless to make what already exists, and it is much more exciting to investigate flavours and dishes which were never envisioned using traditional food ingredients.

A simple calculation shows the immensity of the world to be discovered. If we assume that the number of traditional food ingredients is about 1000 and if we assume that a traditional recipe uses 10 food ingredients, the number of possibilities is 1000 to the power 10, or 10 to the power 30. However if we assume that the number of compounds present in the food ingredients is about 1000, and if we assume that the number of compounds which will be used in note by note cuisine is of the order of 100, then the number of possibilities is about 10 to the power 3000... And, in this calculation we did not consider that the concentration of each compound can be adapted, which indeed means that a whole new continent can be discovered. Why reproduce our small world, then ?

### **Nutritional questions**

Here we should begin by telling that the traditional food is not a guarantee of healthy food : remember that there is today a pandemic of obesity ! Of course, some will criticize the modern diet, but it would be rather more appropriate to observe that the new food environment is not suitable for human beings. Indeed the human species had to face alternating times of plenty and starvation, and nutrigenomics is now discovering mechanisms through which the human body could face these conditions. For example, too much to eat does not lead to increased elimination, as we could wish today, but rather better storage in fat tissues.

The issue of traditional food being solved, let us consider now why note by note cuisine could be

interesting nutritionally. This question has relation with making « light products ». Does the use of sweeteners lead to overconsumption ? The already made studies could guide the study of the long term effects of note by note cuisine.

Certainly, the question of using vitamins or oligoelements, and also minor nutrients should be considered, and this is why the science of nutrition has so many questions to investigate. It would be a mistake to consider that the issue is solved, as an European study of supplementation with vitamin E (the name given to a group of hydrophobic compounds with specific antioxidant properties) was stopped, because of an higher incidence of deaths in the group of smokers receiving the supplementation. Here again, scientific studies are necessary.

### **Toxicology**

This leads now to consider the toxicological question. Yes, we do not know enough the effects of compounds in the body, and frequently wonderful effects are discovered, such as cytochrome P 450 polymorphism, or more recently gene transfers in bacteria which are hosted by algae toward bacteria of the human gut when algae are consumed.

A strange case is estragole, which makes up to 50 percent of the total composition of the essential oils of tarragon and of basil. The hydroxyl derivative of this compound seems to be toxic, but we don't understand why, and there is no particular incidence of liver cancer in populations consuming a lot of herbs.

Indeed, from a toxicity point of view, note by note cuisine will not be done differently from traditional cuisine, for which animal and plant tissues were never tested. This is indeed a paradox of modern diet that novel foods are much more studied than old food for which we know perfectly that no authorization would be given if they were introduced today.

Note by note cuisine can avoid benzopyrenes... if it did not use it. It will avoid the toxic myristicin from nutmegs, estragole, glycoalkaloids from potatoes and tomatoes, some glycosinolates from cabbages, some phenolics from plant tissues, etc. If we don't use them, we shall avoid toxicity... The public, as for it, can do what it wants ( in particular barbecues full of benzopyrenes!).

The issue of regulation of food products will then be analogous to the question of selling liquid nitrogen to « molecular cooks », of selling ultrasonic probes, of selling rotary evaporators..

The evolution of practices will ask for new regulations, as it was the case when gas or electricity were introduced in homes. And we should know that there will almost certainly be accidents, not because note by note cuisine is more dangerous than knives, or gas, but because the culinary world, as any specific community, has its proportion of unconscious people, as this young German guy who put liquid nitrogen in a closed bottle !

Primarily, what I propose to retain from this discussion is that the scientific and technological questions are asked very differently. We have to learn the effect of compounds on the body. It's time !

### **Art, first !**

The concept of art is complex, but I propose, in order to be short, to admit that culinary art, as well as painting, music, sculpture, literature and other arts aims at creating emotions. Artists never stopped introducing new ideas in their works, and gourmands are longing for new flavors, new sensations. Note by note cuisine can make them happy, because it can produce a wealth of new possibilities.

However producing note by note pieces was difficult, because the cooks who tried, as they did not know the syllabus that they could use, could hardly make sentences with meaning. It was difficult, but not impossible, and I have worked so that my friend Pierre Gagnaire (restaurants in Paris, London, Tokyo, Dubai, Hong-Kong, Moscow, Courchevel, Berlin, Las Vegas, Seoul) would be the first cook in the history of cooking to produce a fully note by note dish : after many months of work during which I was helping him, he showed a note by note dish during a special dinner, in Hong Kong, the 24<sup>th</sup> of April 2009. Then, during the summer 2010, the alsatian cooks Hubert Maetz and Aline Kuentz made note by note dishes that they demonstrated during the JSPS meeting (French-German-Japanese alumni), in Strasbourg. Later, in October, the professors of the Cordon bleu school, in Paris, made a whole note by note meal, for a group of 20 participants of the curriculum of the Hautes Etudes du Goût (Advanced Studies in Gastronomy). In January 2011, the day before the official launching of the International Year of Chemistry, Jean-Pierre Biffi and his team of the catering company Potel & Chabot made a note by note meal for more than 100 people, and more recently, in May 2011,

the same meal was served for all chefs having won a Michelin star, at l'Espace Cardin, Paris.

In each occasion, cooks looked for compounds that they did not know, and they learned to use these products in order to make remarkable pieces, with new flavours. Of course, one can hardly explain the flavor of these dishes : how would you explain what the blue color is to someone who cannot see ? Also the question of the name was difficult... but perfumery solved the issue : Channel 5, etc.

For all those who are afraid of losing their stew, cassoulet or choucroute, let us say that as art is concerned, there is no replacement, but only addition, more freedom, more choice. Debussy did not make Mozart or Bach disappear; Picasso or Buffet did not prevent us to admire Rembrandt or Brueghel. And molecular cuisine did not kill nouvelle cuisine or traditional cuisine. Note by note cuisine will be an artistic addition.

### **Economy**

What will be the price of note by note cuisine ? Will it be more expansive than current cooking ? Here the energetic issue has to be considered because the next increase of the cost of energy will perhaps be the key of the success of note by note cuisine. Today, in order to « reduce » wine or bouillon, in view of making a sauce, cooks evaporate primarily water (losing many odorant compounds, lost by steam evaporation). If we assume a reduction such as professional do (for example by two thirds), a simple calculation shows that the energy consumed is 0,417 kWh, which means 0,05 euros per sauce.

More generally, the question of energy was not considered by traditional cuisine, where meat are heated to more than 200 °C, in order to produce compounds which could be immediately reached by note by note cuisine, for which mass produced compounds could be made at a much lower cost (roasting ten chicken in the same oven does not cost more than roasting one, which means that the cost per chicken drops).

On the other hand, it will not be necessary to synthesize the compounds used by cooks, and frequently they will be extracted, from plant material, such as chlorophylls today. Chemists know well that hundreds of chemist-years were necessary to synthesize vitamin B12, so that agriculture and extraction remain the most efficient and in the absence of an efficient



method. Note by note can then use either synthesized produced, or extracted products, no matter where they come from... but there are...

### **Political and social questions**

The first tests of note by note cuisine inescapably created fear, based on the fantasmatic idea that we would eat « chemicals ». Here, as for GMO's, for example, political ideas are confusely mixed to other question, in the discussion. Note by note cuisine can be successful only when it is well explained, and if the authority argument is used, as Augustin Parmentier understood it well whand he served potatoes to the king of France, at a time when the country refused this food ingredient. But should we not be afraid that, as for GMO's,

note by note cuisine will have disadvantages for human organizations ? How would farmers survive when -it is unlikely- all food would become note by note? These questions are more than chemists can answer, but they call for the following answer: as some people are rich by doing wine instead of selling grape, farms could become richer than they are today when they would produce fractions of plants, instead of selling the raw material.

Finally, after considering some questions related to note by note cuisine, the scientific question remains. We could see here in many occasions that many scientific questions arise. This is not new, in the history of chemistry, which developed frequently from « chemical arts ». A new opportunity can now be reached.