Estoril Higher Institute for Tourism and Hotel Studies

Effect of Nostalgia Triggered by Sound – from the *Sound of the Sea* dish – on Flavour Perception

Dissertation and Internship Report

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by

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Table of Contents

Page

List of Figures

Page

Page

Page

List of Tables

Page

List of Graphics

Page

Resumo

Nas duas últimas décadas a área da gastronomia tem vindo a ser alvo de constante mudança, os profissionais de artes culinárias têm vindo a explorar cada vez mais na alta cozinha, não só a ciência no ato de cozinhar como as reações fisiológicas do corpo durante uma experiência gastronómica.

É comum confundir termos como sabor e flavor, o primeiro diz respeito a uma perceção que se dá exclusivamente na boca enquanto o segundo é a junção de vários sentidos e sensações como sabor, cheiro, tato, audição, visão, emoção, memória, entre outros. Flavor combina todos os estímulos no cérebro de um modo único para o ser humano e este fenómeno tem a designação de perceção multissensorial.

Enquanto profissional da área de artes culinárias, a importância de uma formação *on the job* de qualidade é significativa. Assim sendo foi realizado um estágio na Cozinha Experimental do restaurante The Fat Duck com o objetivo de aplicar e adquirir novos conhecimentos e também de efetuar um estudo experimental preliminar de modo a entender qual "O Efeito da Nostalgia Ativada pelo Som – do Prato *Sound of the Sea* – na Perceção do Gosto".

O restaurante The Fat Duck dispôs de todo o material necessário tanto para um correto estudo experimental como estágio, o que permitiu: (i) compreender como um restaurante de alta cozinha aplica a ciência no ramo profissional; (ii) aprender novas técnicas; (iii) consolidar e aplicar o conhecimento adquirido durante o Mestrado em Inovação em Artes Culinárias.

Os resultados do estudo sugerem que através do som é possível ativar um sentimento de nostalgia. Ao passar o som que simula o mar, fez com que os provadores sentissem o prato *Sound of the Sea* mais salgado, mais fresco e delicioso do que quando degustado sem o estímulo do som. Os resultados sugerem também que: a) o tipo de memória afeta a aceitação ao prato b) quantos mais sentidos forem ativados durante a perceção multissensorial maior a aceitação; c) cada individuo experiencia a sua própria realidade de perceção multissensorial.

Palavras-chave: Alta Cozinha; Flavor; Gosto; Nostalgia; Perceção Multissensorial; *Sound of the Sea*.

Abstract

The world of gastronomy has significantly changed in the last two decades – professional chefs have been exploring, in the modernist cuisine field, not only the science behind cooking but the physiological reactions one experiences while eating.

People are often confused with the terms taste and flavour, while the first is related to what happens exclusively in the mouth, the second regards to a series of sensations – such as taste, smell, touch, sound, sight, emotion, memory and others – processed together in the brain in a way unique to humans. This is known as the multisensory perception experience of eating.

As a professional chef, the benefits of on the job training are plenty, therefore an internship at the Fat Duck Experimental Kitchen was accomplished. It was agreed a tasting assay regarding the "Effect of Nostalgia Triggered by Sound – from the *Sound of the Sea* Dish – on Flavour Perception", would be conducted during the internship.

The Fat Duck restaurant provided with all the materials needed for both the tasting assay and the internship, which allowed to: (i) understand how a fine dining restaurant applies science in the kitchen; (ii) learn new techniques; (iii) reinforce knowledge gathered during the Master's degree in Innovation in Culinary Arts and Sciences.

The tasting assay – which had a preliminary approach – suggested that nostalgia can effectively be triggered by sound. When hearing the sound of the seaside participants felt the *Sound of the Sea* saltier, fresher and more delicious overall than when sound was not being played. It also suggested that: a) the type of memory evoked, directly affects the enjoyment of the dish; b) the more senses are activated in the multisensory integration the better the overall enjoyment is; c) each individual lives in his own multisensory perception reality.

Keywords: Flavour; Modern Cuisine; Multisensory Perception; Nostalgia; *Sound of the Sea;* Taste.

List of Abbreviations

ACT – Advanced Culinary Techniques

AFIRM – Analysis of Flavours and Fragrances In Real TiMe©

ATP – Adenosine Triphosphate

DE – Dextrose Equivalent

DTA – Diphtheria Toxin

EHITHS – Estoril Higher Institute for Tourism and Hotel Studies

EPL – External Plexiform Layer

FDEK – Fat Duck Experimental Kitchen

fMRI – Functional Magnetic Resonance Imaging©

FPUCA – Food Products – Uses and Culinary Applications

GC – Granule Cells

GLOM – Glomerulus

GPCR – G-Protein Coupled Receptor

KO-mice – Knock Out mice in specific receptor

LOFC – Lateral Orbitofrontal Cortex

MC – Mitral Cells

MEP – *Mise-en-place*

MICAS – Master in Innovation in Culinary Arts and Sciences

ML – Mitral cell body Layer

MOFC – Medial Orbitofrontal Cortex

MSG – Monosodium Glutamate

MSNF – Milk Solids Not Fat

NA – Nucleus Accumbens

NLDB – Nucleus of the horizontal Limb of Diagonal Band

OC – Olfactory Cortex

OFC – Orbitofrontal Cortex

ORN – Olfactory Receptor Neuron

PG – Periglomerular cells

PROP – 6-n.propythiouracil

RDM – Research and Development of Menus and wine list

RHI – Rubber Hand Illusion

SOM – Somatosensory System

TF – Tufted Cells

TRC – Taste Receptor Cell

TRP channel – Taste Receptor Protein channel

TRPC – Transient Receptor Potential Channel

UV – Ultra violet

VTA – Ventral Tegmental Area

Introduction

Cooking was not always seen as science, not as it is nowadays when presented by the media, although it was of great interest for scientists of the eighteenth century to experiment with food preparations (Blumenthal, 2008).

Benjamin Thompson was one of them, he explored the properties of insulation and convection and made the “insane” suggestion at the time that heat was a form of energy (Blake, 2008). It was then that low temperature cooking took its first steps, when Thompson suggested long slow cooking meat in order to get a very tender and juicy result (Roca & Brugués, 2014).

Another revolutionary scientist and a great fan of Thompson was, considered by many, the father of food science, was Nicholas Kurti (who, among many other things, developed techniques to reach temperatures close to absolute zero) (Myhrvold, Young, & Bilet, 2011). Inventor of the microwave and author of the classic Baked Alaska (a cake frozen on the outside and warm inside), he spent much of his retirement trying to gather chefs and scientists in the name of food science (Leask, 1998).

In 1969 he gave a lecture about equipment that had lot of potential in a kitchen like vacuum ovens, hypodermic syringes and thermocouples, it was in that lecture that he asked the famous question “Is it not quite amazing that today we know more about the temperature distribution in the atmosphere of the planet Venus than that in the centre of our soufflé?” (Blake, 2008).

Many experiments and development have taken place since then, science in the kitchen is no mystery any more thanks to scientists as Nicholas Kurti (Blake, 2008). However there is another subject related to cooking which is not yet completely understood nowadays, to catch up with what has been going on in the science of cooking one has to explore not only chemistry and physics but other subjects such as neonatal, paediatric physiology and neuroscience (Shepherd, 2013).

In the XIX century, Brillat-Savarin wrote in his book *The Physiology of Taste*: “Tell me what you eat and I will tell you what you are”, from what science has discovered this sentence is true in ways which he and we could never have imagined (This, 2007).

As Brillat-Savarin also observed, it is common when asking someone how they know what they have in their mouth the answer to be: because of the taste (Rawson & Li, 2004); the problem is that there is a huge confusion when referring to taste which is about what happens exclusively in the mouth and consists of five tastes we can perceive: salty, sweet, sour, bitter and umami (Chandrashekar, Hoon, Ryba, & Zuker, 2006).

Flavour in its turn involves thousands of aromas that are detected not in the mouth but in the nose, and because those aromas come from volatile compounds released in the mouth to the nose one still confound it with taste (This, 2006).

Another mistake we make is to consider flavour as a sense on its own exclusively, in fact flavour begins in our sense of smell mechanisms (Shepherd, 2013), however, it is known today it plays bigger role in taste perception, flavour is also closely involved with other senses such as sight, taste, sound and emotion and as most references in this dissertation try to prove it is the base for our multisensory perception of food (Auvray & Spence, 2008).

Several authors suggest multisensory perception might be the key to comprehend how we perceive food (Spence, 2008) and explains why we enjoy or not certain delicacies, studying how our brain works and manages this multisensory perception is important to understand how to control individual sensory worlds (Auvray & Spence, 2008).

Other influences related to our perception of food and the world are more abstract, feelings and emotion are good examples and understanding how they are generated and what is it that they do to our perception is important (McGlone, 2008).

In fact, although studied with some extent, multisensory perception of food is still considered a vast field for investigation, bringing further more culinary arts professionals interests in the understanding of these mechanisms while trying to create new or more unexpected experiences to their customers.

In this context, this work starts aiming not only to understand part of the multisensory phenomena experiences while eating but also to have the possibility of training on job in an environment of culinary arts production where food science is part of the food production system.

This dissertation is therefore bilateral, on one hand there was an interest of conducting an experiment in order to discuss the effect of nostalgia triggered by sound – from the *Sound of the Sea* dish – on flavour perception, at the Fat Duck restaurant which hopefully will contribute to the understanding that eating is in fact a multisensory experience and sound in particular can trigger feelings which affect directly our perception of food in more than one way.

On the other hand as stated above, there was also interest of applying and consolidating knowledge gathered from the Innovation in Culinary Arts and Sciences master's degree, as well as learning on job with one of the considered most iconic restaurants of all times, the Fat Duck which is known for revolutionizing cooking into the modern model we see today and bringing the science into the kitchen. At the end of the first chapter a contextualization of on job purposes offered by enterprises is also presented giving an analysis of benefits vs. disadvantages of internships mainly in restaurants.

Therefore the following dissertation is divided into three main chapters, the first is a deep literature review regarding taste and flavour perception, multisensory integration, how the human brain manages them together with emotion and what influence they have on our perception of food.

The second chapter is about the methodology followed through all process of making this dissertation, from presenting the Fat Duck Company and Heston Blumenthal's work – which is very important to understand why this path was chosen in the first place – to the materials and procedures for the experimental assay.

Finally, the third chapter regards discussion and results, from both the internship period at the Fat Duck and the results obtained in the sensory tasting.

Chapter I – Literature Review

1.1. Sense of Taste

There have been major discoveries regarding the sense of taste. More than ever scientists are investigating this interesting subject (Edwards-Stuart, 2008). Taste lies on the five already discovered groups of receptors existing in the mouth: sweet, sour, salty, bitter and umami (Prescott, 2008), and each one of these groups have specialized receptors (Chandrashekar, et al., 2006). For sweet only two were discovered, it is thought we have so few because naturally is not likely for a sweet thing to harm us, which in fact happens for bitter, we have more than thirty specialized bitter receptors and the human body evolved in order to tell what is poison that we may get directly through our defences via eating so it is important to have all this specialized alarms in our tongue (Beauchamp, 2008).

It is in our mouth that our body makes the important decision of swallowing and let whatever we have in it to go inside our system (passing our defences) or reject it and spit it out (Edwards-Stuart, 2008). This fact would not be possible if we hadn't taste buds, which have our taste receptors. We have three kind of taste buds (circumvaliate, foliate and fungiform) and numerous of Taste Receptor Cells (TRC) for each taste we are able to perceive (Figure 1) (Chandrashekar, et al., 2006).

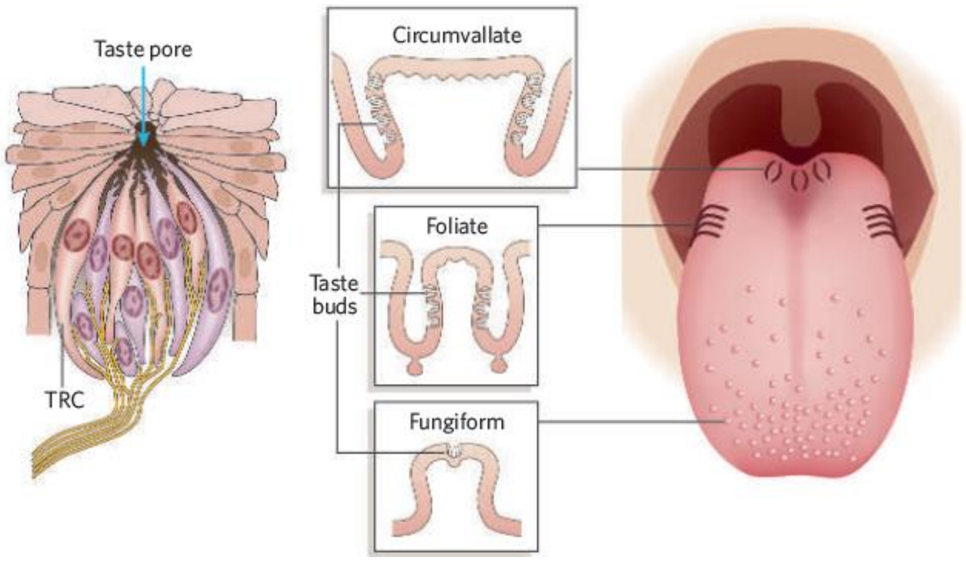


Figure 1 – Structure of taste buds and possible distribution in the mouth (Chandrashekar, et al., 2006).

Taste gets more and more complex as we go forward, a study published in August 2004 issue of Nature discovered that fruit fly has the ability of tasting carbon dioxide. They isolated certain classes of neurons in fruit flies called E409, incorporated with a fluorescent protein and observed that when tasting carbon dioxide it connected to different parts of the brain other than sweet and bitter, E409 responded to various ingredients such as beer, yeast, carbonated water and so on (Edwards-Stuart, 2008).

This is interesting not only for the academic research but imagine that us humans are also able to taste carbon dioxide, genetics between us and fruit flies are not that far apart so it might be possible, if so taste can be a whole new world of complexity that it is beyond our understanding for now (Blumenthal, 2008).

To understand better the complexity that is our sense of taste, taste buds in our tongue have a lifespan between 10-14 days and each time they change new connections are made with the brain and there is no guarantee that they will be exactly the same and although we may not be aware of it our sense of taste is constantly changing (Shepherd, 2013).

As said before, generally speaking the human tongue can distinguish between sweet, salty, sour, bitter and umami. The taste buds, which contain several TRC are located within the papillae on the surface of the tongue (Chandrashekar, et al., 2006).

When we eat something, it dissolves with saliva and then the taste transduction – concept which refers to transfer of information inside of cells leading to chain reactions that end when the brain receives its stimuli – happens, the molecules of food connect to each specialized receptor, proteins or channels and get the correct orientation from then on (Shepherd, 2013).

It was believed until very recently that different areas of the tongue responded to each of the basic tastes but today we know different, that we actually have all types of receptors on our tongue and taste can be perceived within all its area, however some argue that this fact is true but that each individual has different concentrations of specific receptors (Figure 2), meaning we do not perceive a taste with the same intensity in every area of the tongue (Rawson & Li, 2004). And not only bio-chemistry affects taste but also external influences, as seen in a study carried out with a group of people and analysing how long a taste sweet, sour or bitter taste lasted in their mouth. I was observed that when they were put under physical stress there was almost no difference but when

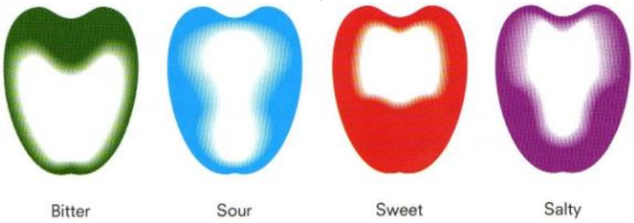


Figure 2 – Possible distribution and concentration of specialized taste cells for each taste (Blake, 2008).

the stress was psychological the results were really different, not only the amount perceived by each of them was reduced but also the maximum intensity of bitterness was lowered (Edwards-Stuart, 2008).

1.1.1. Physiology of Taste

Regarding how we perceive taste there are two major models so far: (i) labelled-line and (ii) across-fibre (Figure 3). Labelled-line says each TRC is specialized on perceiving one single taste (although it is able to perceive other substances, it is activated exclusively for the substance it is designed to) (Erickson, Covey, & Doetsch, 1980). In other words it means, as suggested in Figure 3 a) each TRC has several proteins and ionic channels in its phospholipidic bilayer, capable of perceiving different substances such as sugars, amino acids, etc. but they are activated by only one of them. This fact obligates TRC to have direct neural connection to a specific area in the brain for that particular taste (Erickson, 2000). On the other hand, across-fiber model discusses two hypothesis b) each TRC perceives several tastes (according to the substance connected to its proteins or ionic channels) and connects to several areas in the brain (Caicedo, Kim, & Roper, 2002) or c) taste is not identified when a substance connects to a receptor in the phospholipidic bilayer but inside the cell instead, through extremely complex reactions, connecting later to the brain through a singular nerve (Smith, John, & Boughter, 2000).

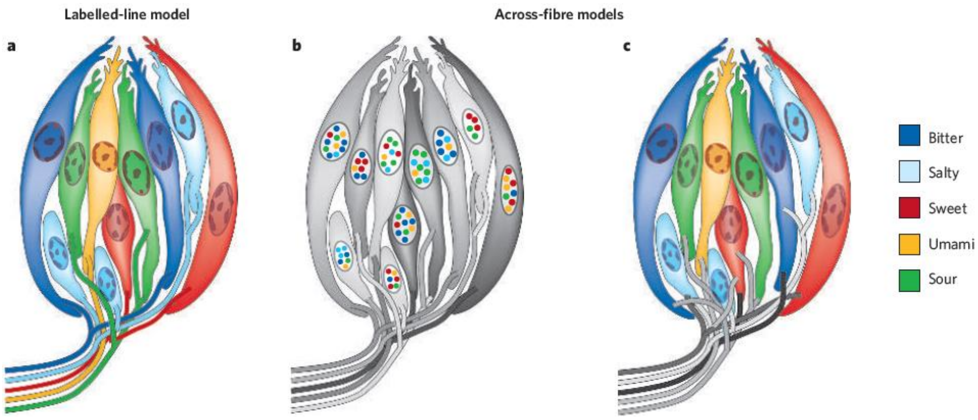


Figure 3 – Labelled-line and Across-fiber models (Chandrashekar, et al.,, 2006).

Both models previously mentioned indicate taste perception at the periphery happens the same way, there is a stimuli from a substance attaching to its specific receptor – G-Protein Coupled Receptors (GPCR) for sweet, bitter and umami (Zhao, et al., 2003), and Taste Receptor Protein Channel (TRP channel) for salty and sour (Figure 4) (Huang, et al., 2006) – signal transduction takes place and a chain reaction is followed, ending in activation of neural impulse and signals to the brain. From the two hypotheses, labelled-line is the most plausible as it will be discussed further (Erickson, 2000).

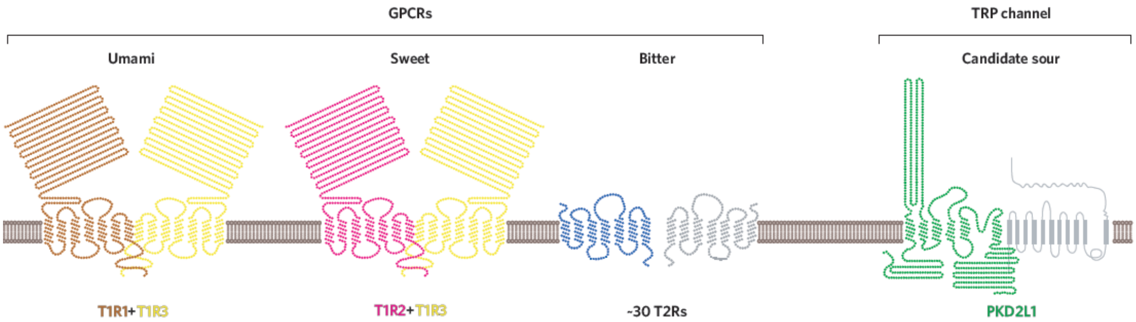


Figure 4 – Receptors for umami, sweet, bitter and sour (Chandrashekar, et al., 2006).

1.1.2. Sweet

Years of research prove that we are naturally supposed to like sweetness, a message from nature that what we are eating is caloric and energetic for our body. It can be seen in new-born babies and commonly in most mammals and persists throughout our life. It is true that some people may be more receptive to sweet than other but in the end – unless you suffer from some physiological disorder – everyone seems to like this taste (Hoon, et al., 1999; Edwards-Stuart, 2008).

Sweet is mediated by GPCRs T1R2 and T1R3 (Figure 4), this was proved by using engineered modified mice knocked out in specific receptors (KO-mice) and T1R2+3 KO-mice had full absence of sweet stimuli in the brain (Table 1) the same was observed when experimented with KO-mice T1R2 and T1R3 separately (Chandrashekar, et al.,2006). Several authors believe T1R3 are specialized in perceiving simple sugars and T1R2 artificial ones (Nelson, et al., 2001), D-amino acids and intensely sweet proteins such as aspartame or monellin, this substances cannot be perceived by mice but when T1R2 was artificially introduced they showed stimuli for sweetness in the brain (Zhao, et al., 2003).

1.1.3. Umami

Until quite recently it was believed there were four tastes but today the fifth – umami – was discovered relatively recently and it is known for its savoury sensation, identifying proteins and/or amino acids in food. It comes from glutamic acids monosodium glutamate (MSG) and aspartate which belong to a big group of L-amino acids (Iwasaki, Kasahara, & Sato, 1985). It can be found in many foods including human mother's milk, fish, meat, milk, tomatoes and some vegetables including mushrooms. Umami can even be enhanced by other molecules such as ribonucleotides present in yeast extracts and fermented dried tuna fish sold in Japan as bonito and used to make the soup stock called dashi. Umami is responsible for the rich taste of many cuisines such as the Italian classic of tomatoes and parmesan. MSG was identified by professor Ikeda at the University of Tokyo in 1909 although it has just been established as the fifth taste in the last ten years.

It is important to refer that umami does not enhance the other four tastes nor it is the "delicious" taste at all, it is simply another taste that we can perceive and either like it or not. So why does it seem like it can sometimes contribute to enrich the deliciousness of food? It appears that when glutamate is associated with a savoury odour such as cooked vegetables, the result can be much more pleasant than the same food cooked on its own.

This phenomenon takes us to the importance of olfactory perception and multisensory perception in the brain – explained later – umami has a beneficial effect yes, if tasted with aroma molecules at the same time (by itself it is unpleasant). If one tries it on its own or with black pepper and salt, the difference is astonishing. Liking it has been observed in very young human infants, suggesting – although far from confirmed – it too may be somehow naturally preferred (Auvray & Spence, 2008; Beauchamp, 2008; Edwards-Stuart, 2008).

Umami is mediated by GPCRs T1R1 and T1R3 (Figure 4) as shown experimenting with KO-mice resulting in the absence of stimuli in the brain (Table 1), the same was observed when experimenting with KO-mice with T1R1 and T1R3 separately (Chandrashekar, et al., 2006). The fact that sweet and umami share the common receptor T1R3 might explain why umami triggers behavioural attraction, especially when tasted with other sweet proteins which also connect to this receptor (Zhao, et al., 2003).

1.1.4. Bitter

Bitterness signals exist to warn our body of a possible poison, however not all bitter compounds are poisonous nor all poisons bitter but the correlation is high (Wooding, et al., 2006). It is thought that bitterness sensitivity evolved mutually from plants which did not want to be eaten and organisms which did not want to eat poison (Shi & Zhang, 2006). Bitter substances seem to be particularly unpleasant for children and that is why it is very difficult to make them eat their vegetables, actually their body is telling them not to eat it because is toxic (Chandrasherar, et al., 2000). For adults liking bitter foods and beverages is a learnt process and it is different for everyone, we may be born sensitive to a type of bitter compound and not for another, the same happens with other people therefore we may assume that we live in different worlds of bitterness perception (Scott, 2004).

As referred before, we have many different receptors for bitterness (Zhao, et al., 2003)and they are not just situated in the back of the mouth (Rawson & Li, 2004), in fact not all people have the same distribution or amount of taste receptors including bitter, some have greater density than others, as already mentioned. There are people who have great amounts of bitter receptors and can perceive bitterness much more strongly than other people. On the other hand there are many individuals who cannot taste bitterness at all (although it is very rare) – this is one of the factors affecting chefs' style of cooking (Edwards-Stuart, 2008).

Regarding the human taste abilities and showing that each one of us really lives in different realities of tasting, the substance 6-n-propylthiouracil (PROP) is a bitter compound that not all people can perceive, those who cannot are called non-tasters and the smaller group who does can are super-tasters. The names are just representative and should not be taken literally as it does not mean or has been proved super-tasters actually have higher taste skills (Chang, Chung, Kim, Chung, & Kho, 2006). These types of variations happen in the gene encoded on a particular chromosome which allows explaining the variations on perceiving PROP bitterness. Other studies suggest we have around thirty specialized bitter receptors in our tongue for the fact that our genome has been encoded through history to prevent poisonous food. The tongue of a supertaster has been studied and they observed that he actually has more density of papillae for every taste, although it does not mean higher perception it might be an indicator, deeper analysis of the data showed women are more likely to be supertasters and these people tend not to enjoy very bitter food such as green cabbage, whisky, and so on (Scott, 2004; Duffy, 2007).

In a study using KO-mice it was showed bitterness is perceived by a distinct group of GPCRs T2R (Figure 4) – cycloheximide (exclusive to T2R5 receptor) was not perceived in the brain (Table 1) (Chandrashekar, et al., 2006). When certain receptors from the T2R family characteristic to humans which mice do not have were introduced, they showed high aversion to bitter compounds such as phenylthiocarbamide and salicin (Muller, et al., 2005).

1.1.5. Sour

Sour taste is really still a mystery to scientists as they do not fully understand it neither why it is one of the five basic tastes, perhaps it was developed by organisms to be able to know when a fruit was ripe and ready to eat – studies suggest it exists to avoid tissue damage from high acidic solutions. Although sourness is part of our everyday life, still very little is known about it (Fisher, 2008).

Sourness comes from acid, from the weak citric acid solution of the lemon juice or the acetic acid in vinegar or even from the lactic acid developed by bacteria in yogurt, it is in our everyday lives and we enjoy it in small quantities. Charles Darwin observed that young children tend to enjoy sourness in high quantities and until today we do not know why it diminishes while growing up. All it is known is that we still enjoy it with as long as it is used moderately (McGee, 2004; Blumenthal, 2008; Fisher, 2008).

There were some interesting discoveries related to cooking. It is known that some acids carry volatile molecules and although we cannot sense them evidently such as other ingredients, different types of acids may improve some types of flavour compounds of food. For instance malic acid not only promotes saliva appearing in the mouth – helping with mouthfeel and the brain thinking that what we are having is really good – but also enhances some fruit such as green apple flavour, the same happens with citric acid and citrus fruit (McGee, 2004; Benzi 2008).

It is among the five basic tastes. For three of the tastes (sweet, bitter and umami) we have specific receptors to which the compound connects (Zhao, et al., 2003), it was thought that acid would dissolve in the saliva in our mouth and would release de hydrogen ions and these would react with all our cells in the tongue (Huang, et al., 2006).

Nevertheless, hydrogen ions alone do not make the sour taste in our mouth, although weak acids such as citric or acetic dissolve in the watery solution in our mouth and break into positively charged hydrogen ions and negatively charged citrate or acetate ions, most of the other acids remain undissolved and they too trigger sourness in our mouth (Fisher, 2008).

Having turned down hypothesis defending sourness was exclusively mediated by potassium channels or Na^+/H^+ exchanging (Lyall, et al., 2004), recent genetic studies showed it is perceived by specialized taste receptor protein (TRP) channel PKD2L1 (Figure 4) (LopezJimenez, et al., 2006). KO-mice PKD2L1 showed total absence of sour taste, proving this receptor alone mediates all sourness perception (Table 1). Saltiness was perceived even with PKD2L1 inactivation, proving it mediated by another independent TRP channel family (Chandrashekar, et al., 2006).

1.1.6. Salty

Enjoyment of saltiness is believed to come from our body's use of minerals which cannot be easily stored, sodium – it is essential for the body's chemical equilibrium and on food it has at least two major functions, it adds a pleasant saltiness and it remarkably inhibits bitterness. The true reasons for liking salt are still not exactly known but they lie somewhere between natural physiological causes and learned through live experience (Beauchamp, 2008; Edwards-Stuart, 2008; Shepherd, 2013).

It is believed it is perceived by individual family of TRP channel Na^+ sensitive, however the true identity of the receptor for saltiness true identity is still not fully known (Chandrashekar, et al., 2006). Studies demonstrate, high Na^+ concentration outside TRC makes the TRP channel to start denature causing slight deformation and letting Na^+ inside the cell, this later leads to signal to the brain. If the concentration inside the cell is too high, sodium/potassium pump starts and energy is spent trying to eliminate the excess positively charged ions inside the cell. At this point the inside of the cell went from the normal -80mv/-90mv to -30mv/-40mv and is more positively charged, giving a small electric sensation similar to when perceiving acid solutions (Lyall, et al., 2004; Shepherd, 2013).

1.1.7. Temperature and Pain

Ingredients as spicy peppers give a heat sensation and pain in our mouth, this is caused by a compound named capsaicin. It triggers our sensitive cells in the tongue and lets us know we have that substance there: these receptors were discovered in the tongue at the same time they were in our body, our heat sensitivity cells let us know that what we are getting burned (Beauchamp, 2008).

Heating is sensed by the same receptor cells as cooling, as it is perceived when eating menthol. The production of capsaicin was developed by some plants as a defence mechanism for when they were eaten, the animal would think their mouth was on fire and never touch it again (Edwards-Stuart, 2008).

We have temperature, pain and touch sensitive terminals in a specialized group of nerves in our mouth called transient receptor potential channel (TRPC).

They can be activated by chemicals, temperature or even minimum amounts of vibration. Together they signal to the brain information of what we have in our mouth, the data is later processed by our somatosensory system (SOM).

Chili pepper is very famous around the world and it is the most popular spice and it is only perceived as chili because of the heat sensation it gives – we enjoy certain amounts of pain in our mouth, however it is evident that it is an acquired taste because children do not like it at all.

The reason why we enjoy small amounts of pain by heat in our mouth is because of a chemical called dopamine, when we feel pain, our brain sends certain endorphins which act as anaesthetic, relieving the pain, after this dopamine is released our reward system is activated – which will be discussed later (McGlone, 2008; Prescott, 2008; Shepherd, 2013).

1.1.8. Taste Transduction

Trying to understand how taste signal at the periphery is transduced (converted) to inside the cell for sweet, bitter and umami tastes it was observed that a particular enzyme Plc-β2 and a protein Trmp-5 (Zhang, et al., 2003). The second one acts as cation channel releasing Ca^{2+}

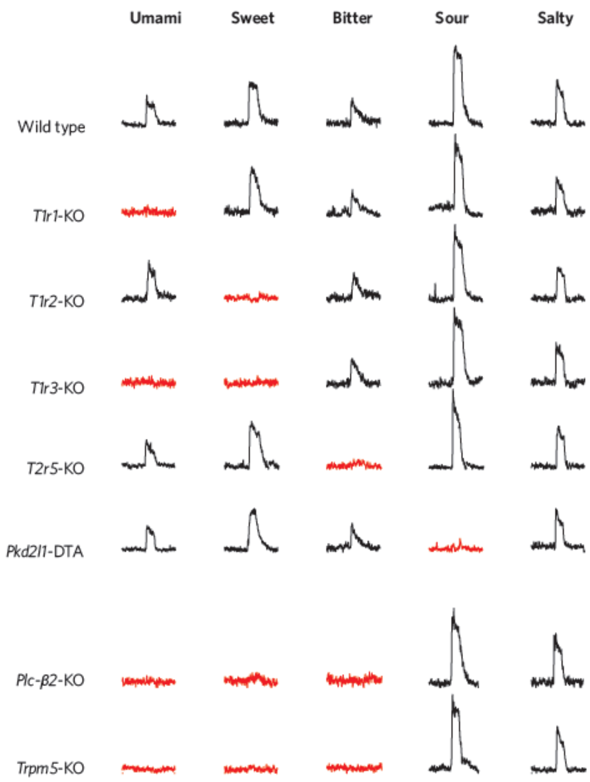


Table 1 – Sweet, umami, bitter and sour are mediated by specific receptor cells. PKD2L1 is a candidate for GPCR channel for sourness. Transduction agents Plc-β2 and Trmp-5 are needed for umami, sweet and bitter taste (Chandrashekar, et al., 2006).

- this cation is the responsible for most coding and triggering signals in the human body and that is why we do not have it running freely in our system (Richter, Caicedo, & Roper, 2003). Both are needed for these taste transductions, this is proved by total absence when KO-mice Plc-β2 and Trmp-5 individually are given sweet, bitter or umami substances (Table 1) (Chandrashekar, et al., 2006).

It was later discovered that all five tastes are lost in KO-mice P2x2 and P2x3 (Chandrashekar, et al., 2006) – purigernic receptors from P2x family activate exclusively with the presence of adenosine triphosphate (ATP) and are known to be essential for sense and pain perception – these results show ATP is one of the agonists in taste perception and is required for other neurotransmitter release for further signal to the brain (Finger, et al., 2005).

1.1.9. Labelled-Line Model

A study with KO-mice Plc-β2 showed when the enzyme was restored in a particular receptor, for instance T2R only the bitter taste had stimuli in the brain. This fact helps proving labelled-line model is more plausible, otherwise if across-fiber model was true when Plc-β2 was restored, no matter what the receptor all three tastes it mediates would be restored as well (Chandrashekar, et al., 2006).

An experiment with genetically engineered mice introducing an external modified receptor k-opioid in sweet or bitter receptor showed how possible labelled-line model is. The modified receptor k-opioid is exclusively activated by the synthetic compound and agonist spiradoline (tasteless). Mice with k-opioid receptor in sweet receptors felt great attraction for spiradoline, on the other hand mice with k-opioid in bitter receptors showed high aversion to spiradoline. This proves across-fiber model is not needed for sweet and bitter tastes and enhances the need for labelled-line model and specific receptors for each taste (Redfern, et al., 1999).

Another experiment took periphery sweet receptors and introduced them into bitter TRCs and the opposite was done as well. It resulted in high aversion to sweet compounds in mice with periphery sweet receptors in bitter TRCs and attraction to bitter compounds in mice with bitter periphery receptors in sweet TRCs. It shows sweet and bitter only depends on the activation of their specific TRCs – in this case T1R versus T2R family and do not depend on the type of receptors they have at the periphery.

Other experiments related to sweet, bitter and sour tastes, TRCs families were eliminated permanently using diphtheria toxin (Mice with DTA in T1R, T2R and PKD2L1 individually lost taste of only one taste related to the family eliminated – T1R lost sweet, T2R lost bitter and PKD2L1 lost Sour.

Therefore we may determine: each taste has its own specific TRCs family; T1R, T2R and PKD2L1 are essential for sweet, bitter and sour taste accordingly; mammals perceive taste without the need of an across-fiber model but with the labelled-line instead (Muller, et al., 2005; Chandrashekar, et al., 2006; Huang, et al., 2006).

1.2. Sense of Smell - Flavour

When we breathe in (orthonasal olfaction), our body relates the odour as smell, on the other hand when we are chewing and the volatile molecules float to our nose breathing out (retronasal olfaction) it is sensed as flavour (Benzi, 2008).

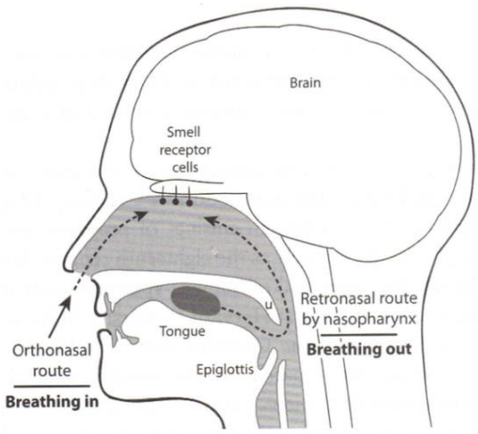


Figure 5 – Cross-section of the human head (Shepherd, 2013).

Comparing our perception of aromas mechanism by retronasal olfaction (Figure 5) we can observe that we have developed through history a shorter nasopharynx retronasal route. This is evidence enough of our superior capacity to deal with food and odour more efficiently through retronasal olfaction, the dog and other mammals however, have a long tube for orthonasal olfaction (Figure 6) as well as a nasopharynx, thus being more efficient to perceive odour by orthonasal olfaction (Herper & Wells, 2006; Lieberman, 2011; Shepherd, 2013).

Curiously we are often tricked by our tongue, and taste perception systems in the brain to think the taste of food we eat is from the mouth. In fact only around 15-20% overall is taste, the other 80-85% is retronasal olfaction – which is later transduced to the brain into flavour (Linforth, 2008).

Smell and flavour have a huge impact on our perception of the world and this fact is understood by commercial companies, and car manufactures inject leather smell into to a car to make it appear top-quality, coffee companies often inject roast coffee aromas into the bottles so when people open them they feel sort of a freshly grounded aroma (Spence, 2012).

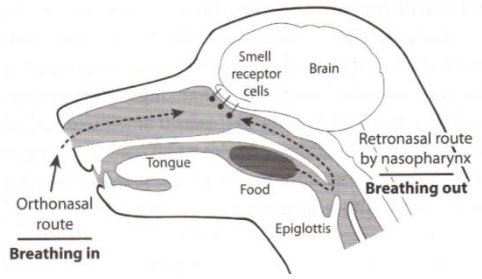


Figure 6 – Cross-section of a dog's head (Shepherd, 2013).

Odour, later perceived as flavour is largely detected in the olfactory bulb, however this is hardly known by people and usually we confuse it with taste. They are distinct from each other, a simple experiment makes it easy to understand. Just by putting a mix of sugar and cinnamon in our mouth with our nose pinched we will sense a sweet taste, release the nose and we register something completely different, the cinnamon flavour is perceived and the experience changes. This is just a glimpse of the complex and hidden machinery behind flavour and around the world of eating (Blake, 2008; Prescott, 2008).

Flavour is complex and its definition often confused, in this dissertation we will start with a base definition – perception of aroma via retronasal flux – and as the reader continues more complex information is reviewed. In the end flavour is not just perception of aromas, it groups together other senses (Spence, 2008).

The worlds of odours or aromas are vast and even a brief exploration showed us how complex it is, between the thousands of volatile compounds that exist, combinations with these can be made to create new ones. It brings just about an infinite group of possibilities and is far from easy.

There are businesses which specialize in separating aromas from natural products and work with them as ingredients for further combination.

In one hundred kilo of strawberries from which we would like to obtain its aroma in pure form, eighty per cent would be cut out being the amount of water in the fruit, along with cellulose which is the flesh and plus sugars, acids, colour, mineral salts, vitamins and other things removed we would end with 100-200g of a powerful liquid of all one hundred kilo sample of strawberry (This, 2006; Gilbert, 2008; Taylor, 2008).

This liquid may be later divided into individual molecules, the strawberry aroma is a combination of hundreds of volatile molecules, however many have little effect on its odour and may be extracted, in the end it is possible to have a strawberry flavour for about twenty different volatile molecules, the major ones that compose it (Taylor, 2008). The same happens with all kinds of raw ingredients, the complexity is enormous and not always easy to control.

Volatile molecules are extremely sensitive and easily change structure even from the lightest influence. Take for instance a development that was taking place at the Firmenich SA aroma company when trying to create a cola involving a formula with a particular bark extract, the supplier was from Russia and when the company had to exchange for a Chinese one the flavour of the beverage changed, after analysing the weather conditions between the two they observed that the Chinese had less 15 per cent of ultra violet light (UV) exposure than the Russian, when putting under the right amount of UV the flavour went back to the same (Benzi, 2008; Gilbert, 2008).

This kind of knowledge is invaluable to cuisine, some plants start losing aroma molecules as soon as they are picked, and on certain substances adding a specific aroma may enhance and make it better (Blumenthal, 2008), ultimately it is the combination between volatile molecules which allow the modern chef to create extremely complex dishes. A simple example is by adding a drop of a particular hexanol to a parsley purée, it brings an extraordinary freshness to it (Linforth, 2008).

Hexanol for instance is a group of volatile compound that allows us to perceive the green notes in most food (PubChem, 2014), the heavier the molecules in this group represent odours such as pear and banana, and the lighter for green apple and freshly cut grass (McGee, 2004). In cooking there is no interest in just separating these compounds, but deep understanding might lead to wonderful new creations (Linforth, 2008).

Years of studying have permitted to reproduce aromas from all sorts of ingredients, take for example vanillin the main volatile compound in vanilla which can obviously be extracted from the bean, but can also be synthetized from rice or lignin (wood) just by isolating the main molecules which form vanillin (This, 2007).

The potential for the professional chef is high, scientists have been studying flavour deeply, they found infinite combinations and are starting to understand how they may go together, volatile molecules of the same profile are more likely to be appreciated when tasted, for the professional chef it means that if liver and jasmine have similar flavour molecules profile it is more likely they will go well together, although this is not always applicable (Benzi, 2008; Gilbert, 2008).

1.2.1. Flavour Release

As said before, in order to perceive a flavour the volatile molecule has to travel from the mouth to the nose via retronasal olfaction, and all the way to the olfactory epithelium contrary to smelling which a is a orthonasal movement and the brain perceives it differently (Lieberman, 2011).

Flavour had not started to be studied until recently, several attempts on building prototype machines that could measure the person's breath in order to calculate how much of volatile compounds were getting out, therefore being perceived by our retro-nasal cavity.

Eventually this machine was designed and was running well, its name AFFIRM – Analysis of Flavours and Fragrances In Real TiMe – it was observed in several studies, for instance the effect fat, proteins and sugar have on flavour release from the mouth to the nose, they found that fat not only limited the type of volatile molecules that it had (only fat-soluble) but it decreased the releasing ratio as well, in practice means it will not be going up to the nose straight from the mouth but maybe half way in the throat taking more time to be perceived (Taylor, 2008).

Droplets of flavour may hold the key to enhance a certain foods, huge but quick bursts of flavour really help increasing the experience, depending on the type of food chefs must think of which is the best way to encapsulate it, being a fat soluble volatile it will be better eaten with a watery solution for an easier passage to the nose and vice-versa (McGee, 2004; Linforth, 2008).

1.2.2. Flavour Perception

Odour is so naturally important to mammals that, as it was discovered in an experiment by Linda Buck, we have approximately 1.000 olfactory receptors types built by 1.000 different genes (Buck & Axel, 1991).

The experiment consisted of a brand new technique (developed at the time) called polymerase chain reaction which basically allowed to find sub categories of cells within larger groups, in the aroma world it meant discovering the olfactory sensory neurons distributed in the olfactory epithelium (Shepherd, 2013).

They also found that all olfactory receptors are in fact G-protein coupled receptors (GCPR), located on the extreme of these neurons at the cilia (Malnic, Hriono, Sato, & Buck, 1995).

All these neurons and receptors in the olfactory epithelium connect to the olfactory bulb and signal the brain (Figure 7) (Shepherd, Chen, & Greer, 2004).

We have around 35.000 genes in the human genome, since we have 1.000 specialized it is surprisingly significant the amount used to build olfactory receptors – around 2,9 per cent.

Curiously, in humans only about 1/3 of these olfactory receptor genes are operational, possibly because sight has become sharper and developed so much due to its importance in our lives, that is why it is usual to take food by its looks right when it is delivered to us (Beauchamp, 2008).

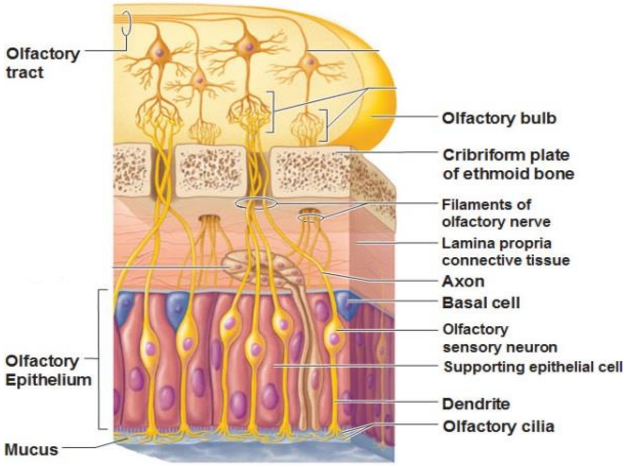


Figure 7 – Main cells of aroma receptors and perception. http://antranik.org/wp-content/uploads/2011/11/smell-olfaction-epithelium-cilia-olfactory-sensory-neurons-and-basal-

However recent studies show each person has different types and amount of operational olfactory receptors meaning aroma is experienced uniquely by each individual (Prescott, 2008).

On top of that, each odour molecule is perceived by combining with the olfactory epithelium which is able to perceive several molecules at the same time joining the perception together and mapping them differently (Xu, Greer, & Shepherd, 2000).

This means that when we perceive coriander and olive oil together we actually perceive an aroma resulting from the two (as if it was just one individually) and not coriander and olive oil both at the same time, distinctly (Youngentob, Johnson, Leon, Sheehe, & Kent, 2007). So we can assume by that that the odour world is multidimensional, multiple combinations are possible and mapping is needed to perceive one flavour molecule from the other (Youngentob, et al., 2007).

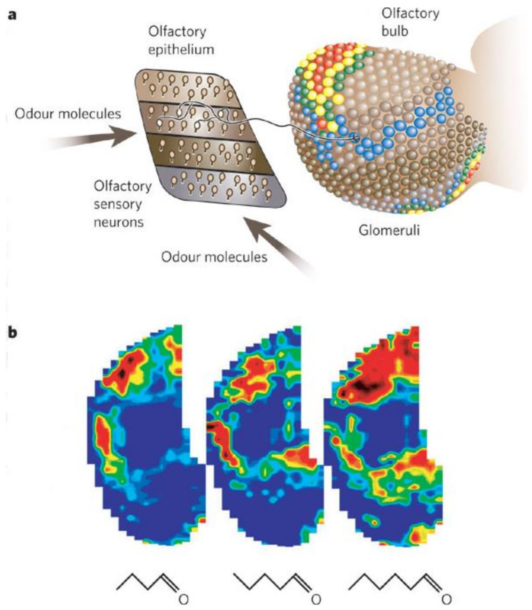


Figure 8 – Olfactory perception. a) olfactory receptor neurons distributed in the olfactory epithelium connected to the glomerular layer, the shades and colors represent the activity of each. b) Mapping patterns for a single odor molecule by adding a carbon atom, suggesting different images are formed on odor perception (Shepherd, 2006).

The glandule responsible for odour perception is called olfactory epithelium and it has more than three hundred receptors capable of cross linking to aroma molecules in different patterns making possible to detect a huge number of different aromas. The perception happens as the volatile molecules float from to our nasal cavity as we eat by retronasal olfaction and attach to our GPCR. The olfactory receptor neuron (ORN) then sends the information (via axon) to the glomerular layer in the olfactory bulb (Figure 8) (Xu, et al., 2000; Shepherd, 2006).

Volatile molecules connect to different receptors on the epithelium matrix and the cross linking differs from shape to shape, one more carbon atom in the molecule or even the tridimensional position of a single atom makes all the difference – it connects differently to the epithelium and therefore results in different perception (figure 8) (Shepherd, et al., 2004).

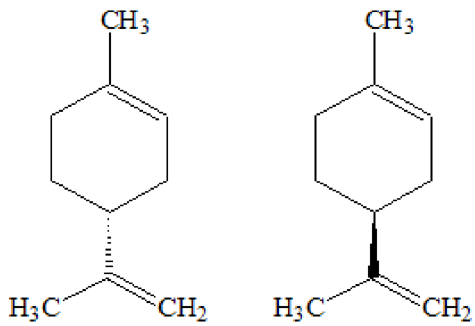


Figure 9 – Isomorphism of molecules. Left: orange odor molecule. Right: lemon odor molecule. http://2014.igem.org/wiki/images/2/2f/Paris_Saclay_project-odor-limonene.png

That is why we can easily feel the difference between orange and lemon even the main aroma molecules being literally mirrors of each other (Figure 9) (Benzi, 2008).

The epithelium's neurons are connected directly into the olfactory bulb which is the section of the brain concerned to odours (Shepherd, et al., 2004).

As suggested before, we are able to map odour perception, and doing so our brain creates an image which is later interpreted in other specialized areas.

This kind of image is not like the ones we are used to perceive with our eyes, they are generated by our brain and they have their own uniqueness as each person's brain has its own perception of the world (Shepherd, 2006).

When the aroma molecules bind with an olfactory receptor neuron (ORN) all that cell "knows" is how much that aroma has tickled its binding GPCR.

The greater the tickle, the more the cell responds to the stimuli by generating impulse (Xu, et al., 2000).

By this impulse (which is the code the ORN sends to the olfactory bulb) the olfactory nerves (ON) are stimulated at the same frequency, which individually does not tell much about what aroma we perceive (Youngentob, et al., 2007).

This means that the code for aroma molecules, the code interpreted by the brain must lie in the difference between the responses in all the different cells activated, therefore aroma perception is an interpretation of a pattern – an image (Youngentob, et al., 2007).

In the olfactory bulb, the fibers from several hundred receptor cells converge on a single area, the glomerulus (GLOM). Each GLOM receives its own unique input, connected to it are some large cells called mitral cells (MC), which have long fibers that go (along with smaller but numerous versions called tufted cells (TF) situated at the external plexiform layer (EPL)) all the way through the mitral cell body layer (ML) and the olfactory bulb into the olfactory cortex (OC) (Shepherd, et al., 2004).

These two types of cells together (at the glomerular level) are called periglomerular cells (PG) and at the level of mitral and tufted cell output they are called granule cells (GC).

At the olfactory cortex the cells recieve the input from the olfactory bulb and connect to interneurons (Shepherd, et al., 2004). It is at the OC that a pre-interpretation of the multidimentional image (from the outside world) takes place and is coded into perceptual features of the inside world in our brain and compared to preavious memory related images (Shepherd, Chen, Willhite, Migliore, & Greer, 2007).

Therefore the OC is invaluable to smell and flavour perception. This interchange phase is modulated by the nucleus of the horizontal limb of diagonal band (NLDB), from the NLDB the signal passes to the orbitofrontal cortex (OFC) and the actual perception is interpreted as it exchanges information with areas of the brain related to memory and emotion (Figure 10) (Migliore & Shepherd, 2008).

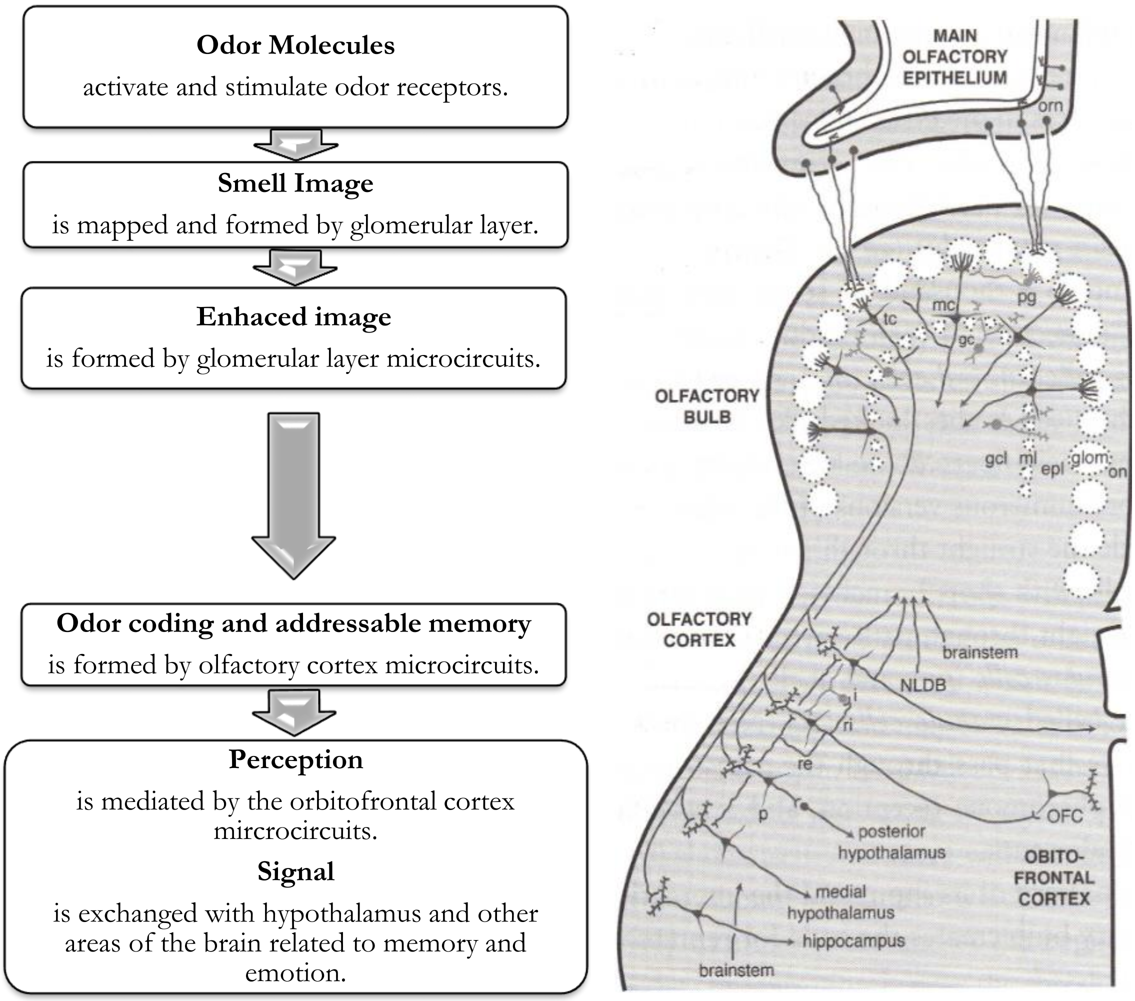


Figure 10 – Left: Main operations for odor image formation. Right: Main cells and areas involved in odor perception (Shepherd, 2013).

And there is more about flavour than the biochemistry of its receptors, when the information reaches, as referred, areas in the brain such as the orbitofrontal cortex it gets complex.

The brain receives the information, processes and represents it along with other inputs from different systems, the result is a combination of all these different images and the phenomenon is what we call flavour (Figure 11) (Wilson & Stevenson, 2006; Blake, 2008).

Therefore, it is here at the OCF that what we call the “taste” (flavour) of, for instance umami of soy sauce, truly happens, resulting of MSG connecting to our taste receptors (sending information to the brain) and odour molecules arriving at the same time at the nose from retronasal olfaction (from the olfactory bulb directly to the OFC), interpreted together (Yarmlinsky, Zuker, & Ryba, 2009).

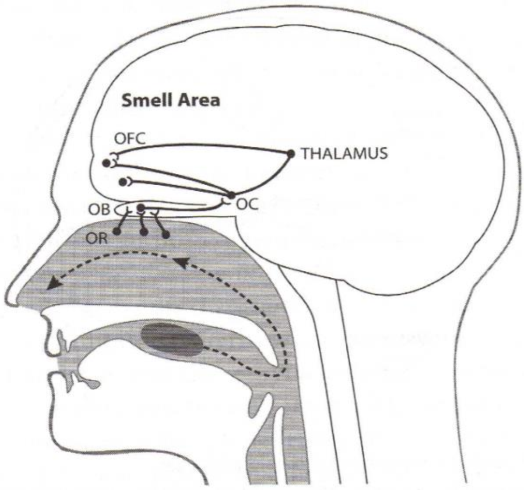


Figure 11 – Cross-section of the brain showing the orbitofrontal cortex and main regions involved in detecting olfactory signals. OFC – Orbitofrontal Cortex; OC – Olfactory Cortex; OB – Olfactory Bulb; OR – Olfactory Receptor Cells (Shepherd G. M., Neurogastronomy, 2013).

However flavour is more than taste and aroma, in fact it is the mixing of all kinds of stimuli such as taste, odour, texture, temperature, etc. which in different combinations create endlessly different images and types of flavours (Verhagen & Engelen, 2006).

In the end flavour is a complex sensation created by our brain involving all of our senses, such as the somatosensory system, taste, sound and others (Delwiche, 2004).

Proof of this multisensory perception will be discussed later in detail. We know this is possible for smell and flavour because they are privileged senses in our perception of the world. They have direct pathways provided by the pyramidal cells such as mitral and tufted cells to the OFC. In this “chief of smell” there are similar pyramidal cells capable of exchanging the information with other critical parts of the neocortex such as the amygdala involved in emotion and parts of the prefrontal cortex involved in flexible learning, decisions and behaviour influenced by reward mechanism (Figure 12) (Shepherd, 2006; Yeshurun & Sobel, 2010).

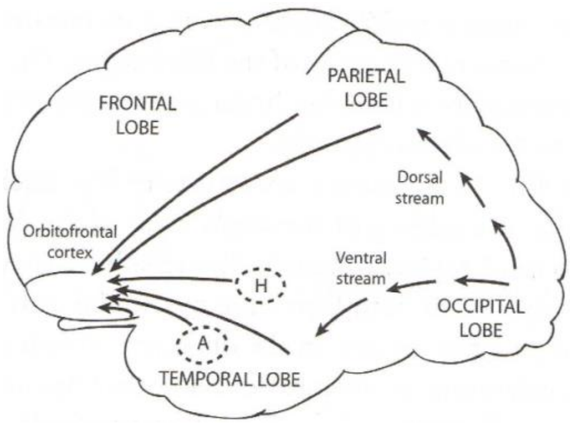


Figure 12 – Main brain regions connected to the orbitofrontal cortex (A) Amygdala; (H) Hypothalamus (Shepherd, 2013).

The prefrontal cortex is unique in humans, it is situated in the core of the part which makes us who we are, it is in this area the true human nature exists (Shepherd, 2013).

1.3. Multisensory Perception

"Eating is a multisensory experience" (Blumenthal, 2008, p. 484) – There are many people and among them chefs who tend to dismiss and say this is overanalysing the subject, but as we have seen throughout this literature revision there is no denying that flavour depends fully on other senses perception (Spence, 2008).

From the moment when we wake up, for instance on a Sunday and take that late breakfast and help cooking the roast leg of lamb for lunch, the smells in the kitchen, the light coming by the window, that morning show that is playing as background in the living room, the sizzling as the roast leg of lamb is coming out of the oven, the crisp of properly roast potatoes to go with it and that marking sight of carving the piece – and again aroma at the table, blending with the emotion of having a great family time.

Most people love Sunday's out with family but we are often not aware of the whole picture of how much this experience is governed by the combination of context and sensory inputs to our flavour images (Auvray & Spence, 2008; Prescott, 2008).

For almost thirty years scientists have been studying multisensory experience and the first studies were carried out in order to understand how some senses work when isolated, sometimes low vision accuracy people say they can hear better when they put on their glasses. An experiment simulating a very noisy cocktail party showed when people could only use sound or sight to understand what the other person was saying, that it was every difficult, the scenario changes when they can listen and see what the person is saying (Figure 13). This fact can also explain why wearing glasses makes short-sighted people hear better (Spence, 2008).

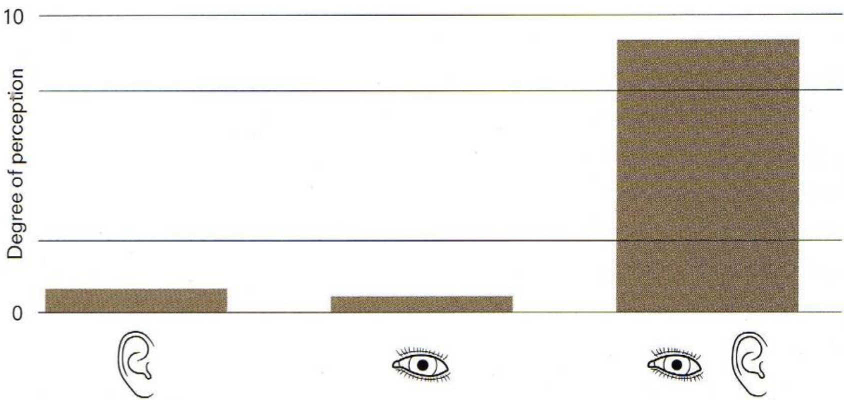


Figure 13 – Understanding words in noisy background, difference between listening, hearing or both (Spence, 2008).

Today's technology such as the functional magnetic resonance imaging (fMRI) is at our disposal and allows us to take pictures of layers of our brain, this technique allowed to prove how senses are triggered in our OFC and how they is intimately connected to one another, resulting in a multisensory experience (Figure 14). Smell is the one which activates more areas and this is happens because aromas have privileged pathways directly to our OFC as discussed before (Li, et al., 2010; Knoferle & Spence, 2012; Fleming, 2014).

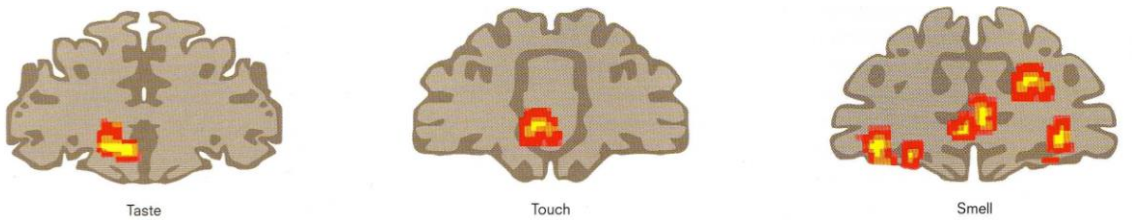


Figure 14 – Cross-Section of the orbitofrontal cortex. It is activated by different pleasant feelings of taste, touch and smell (McGlone, 2008).

Several results which are discussed further might help to explain part of the complexity of multisensory perception and why we perceive some food and drink with high pleasure for instance when we are on vacation, but are often disappointing when those particular foods are brought home (Knoferle & Spence, 2012), the answer lies in the context and nostalgic image in the OFC, if the coding (stimuli) of the smells, the sounds, the sights and so on are not the same, the image will be different from the one that triggered pleasure in the first place (Verhagen & Engelen, 2006).

1.3.1. Synaesthesia

Scientists have been giving us a much bigger glimpse of what goes on when we eat, the discoveries are fascinating and elucidative not just for the professional chef but for everybody (Ward, 2008). Understanding the part each of the senses plays in our appreciation of food, and how much it dependents on the brain to process the information, shows not just how we interact with food but with the world around us (Spence & Deroy, 2013). It really does tell us who we are. Each of us sees, hears, and tastes differently, therefore we all live in our own sensory worlds (Shepherd, et al., 2007).

Synaesthesia was, for many years considered a disease which had no cure, patients had the "malfunction" of having two senses directly connected, in practice it means they would develop a particular feeling or sense by a word, or sound, for instance feeling that the colour red tastes bitter. For a certain type of synaesthetic patients words are connected to taste, therefore when they hear or think of a word they can actually feel its taste - whatever it is, strawberry, coffee, etc. We can say that this type of synaesthesia is a very advanced form of multisensory perception, there was a test made on a subject whom they gave a strawberry and while he was eating it, the word "quick" would be played – which triggered creamy flavour in him – he could actually feel the taste of strawberries with Chantilly (Ward, 2008; Barnett, 2011; Knoferle & Spence, 2012).

Today we know synaesthesia is not a disease and neither does it need any cure, we all suffer from some type of synesthetic condition, as showed before we have the ability to connect one sense to another, as the experiment with low-high pitch or even in a simpler form, the colour red with sweet taste conducted by Charles Spence and discussed later in this dissertation. It is known it happens but the reason why is not fully understood, however the potential of studying it to uncover more of what happens in or brain in terms of flavour perception is evident.

Nowadays we know everyone has synaesthetic tendencies when it comes to taste, i.e. relates and triggers more than one sense. Now that this knowledge has come to public with simpler access, sound is going to play a bigger part in our tasting menus. The potential is evident, for instance Ben & Jerry's is considering a sonic range of ice-cream flavours (Ward, 2008; Barnett, 2011; Spence & Deroy, 2013; Fleming, 2014).

1.3.2. Flavour and Taste

On making pâtés de fruit and trying to achieve the perfect texture Heston Blumenthal, Chef proprietor of the Fat Duck Restaurant got to a point where controlling acid, pectin and sugar content held the key for that wanted texture, when adding a higher amount of acid than needed on a beetroot pâte de fruit it changed flavour profile to blackcurrant, the same happened with many other flavours: fennel became lime and pumpkin became apricot. Our already pathway associated to beetroot in the brain triggered by looking at the substance and see purple-red substance was somehow re-direction to another pathway leading to blackcurrant when the acidity in it was perceived in the mouth (Blumenthal, 2008; Fisher, 2008).

When making the slightest change in volatile molecules the results may be very different because they are very sensitive, for instance linalool from the terpene family found in among other things bay leaves, mint, cinnamon and roses, when tasted in salty solution turns to coriander and in sweet solution to bergamot, warming this one a little bit might even bring some notes of Earl Grey tea (Beauchamp, 2008; Benzi, 2008).

An experiment conducted by Dr. Pam Dalton has shown that people can easily identify the flavour of almond when a tiny drop of a sweetener is tasted at the same time and interestingly this only applies to Europeans and North American Cultures (Figure 15) (Dalton, Doolitlle, Nagata, & Breslin, 2000). The study was carried out with Japanese subjects and they did not understand it as almond, rather just sweet taste, on the other hand when a salty taste (in this case monosodium glutamate) had replaced the sweet they identified the almond flavour a lot easier (Figure 15). If as these findings suggest cultural factors also define flavour profile then we need to identify certain ingredients (Spence, 2008).

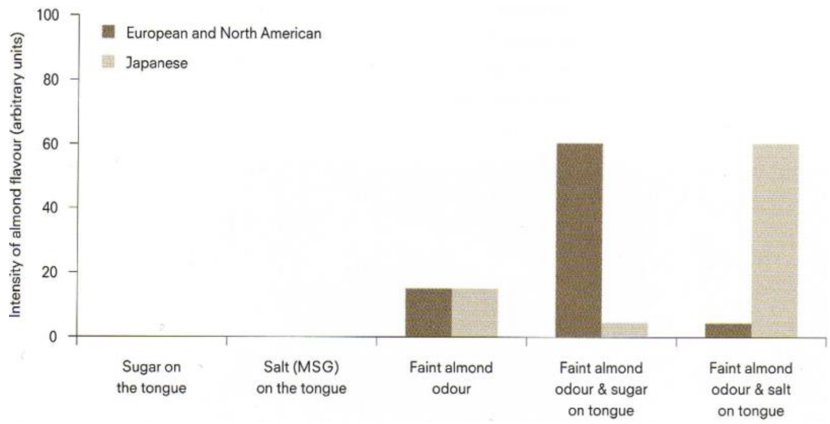


Figure 15 – Taste (sweet Saccharin, salty MSG) and smell (Benzaldehyde) combine to trigger flavour image, but this effect can vary depending on the gastronomic culture (Spence, 2008).

Experiments with mint chewing gum to analyse the relation between taste and flavour, gave some insight of how our brain perceives both. They would collect several samples from the saliva in the mouth and record the volatile coming from the nose, in the end it was observed that when there was still sugar in the saliva mint flavour was strong but when sugar run out, the subject did not feel mint anymore although the AFFIRM was recording the same amount of volatile concentration. The brain associates taste and smell together and creates an image in the brain on the OFC with the pattern of the two, when – in this case – sweet ceases to exist, the image is incomplete and we do not perceive it as mint chewing gum anymore (Shepherd, 2006; Taylor, 2008).

These findings suggest our brain is able to perceive not only the sense of smell and taste separately but together as well, activating more areas for the new image interpretation. This happens because the sense of taste is connected directly to the thalamus and sent to not only to areas such as the insula, covered by a layer called the operculum (specific for taste interpretation) but to the OFC as well (Figure 16) (Spence, 2008; Shepherd, 2013).

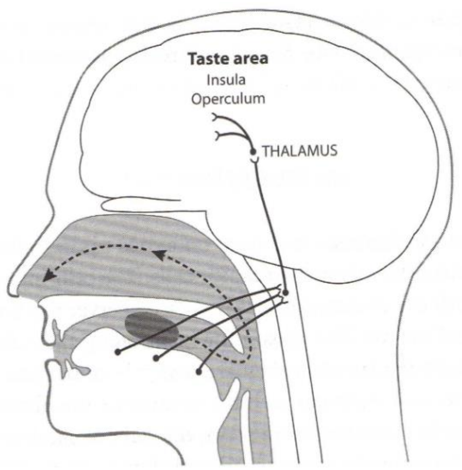


Figure 16 – Human main taste system areas (Shepherd, 2013).

When we taste something and receive information from retronasal olfaction as we are chewing the two combine and our brain perceives them together (Verhagen & Engelen, 2006).

Flavour molecules perception, as suggested above, also change with non-volatile compounds, and it is here it becomes extremely complex and very hard to reproduce, cooked foods such as stews, bread which develop Maillard reaction – not fully understood until this day – are far more complex than the ones picked directly from a tree. These facts bring us to a whole new world of possibilities and leave some questions unanswered such as what actually makes a stew with bone marrow so delicious? Why does a shortbread baked with butter have much richer flavour than one baked with margarine? (McGee, 2004; Benzi, 2008)

However, it is certain that taste and retronasal olfaction play a role in the multisensory integration of flavour (Small, Gerber, Mak, & Hummel, 2005).

1.3.3. Flavour and Texture

If flavour is even more than just taste and odour, texture of food is also very important, for instance we need various fatty-acids in our diet and we need to detect that fat in the food we eat, not to mention that that fat gives a lot of calories (ideal when our body is starving and not so pleasant when our energy needs are balanced, physiologically speaking) (Beauchamp, 2008).

Scientists are still trying to find why the body enjoys fat but they are sure mouthfeel is extremely important when talking about food acceptance, however they do not know if there are specified receptors in our mouth which can detect fats and oils (Edwards-Stuart, 2008). One thing is certain, the tongue is very sensitive and does a great job distinguishing different textures in our mouth, when chewing the food gets pushed against the top and measures are taken, different spots can easily detect if what we are eating is creamy, crunchy, liquid, viscous, etc (Verhagen & Engelen, 2006).

We have specific receptors in the mouth which send the information to the thalamus and after to the somatosensory area, the SOM cortex. As it would be expected we also have touch and chemical sensitive receptors in our nose, they warn us of the smell of ammonia, or the fizziness of carbonated drinks which signal the brain at the same time (Figure 17) (Wang, et al., 2002; Shepherd, 2013).

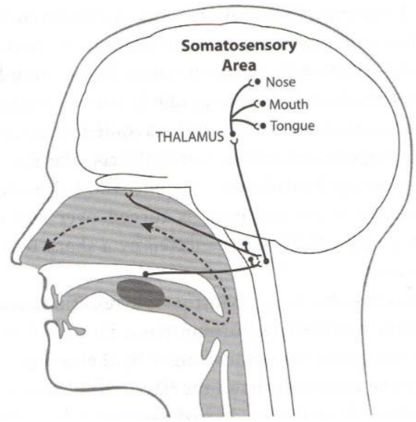


Figure 17 – Human main somatosensory system areas (Shepherd, 2013).

We have discussed flavour is a multisensory experience and as it would be expected touch is part of flavour and is correlated to taste and smell in several ways (Auvray & Spence, 2008; Shepherd, 2013):

- Temperature affects the perception of texture of a substance in the mouth;
- Hot and pain sensation caused by capsaicin reduces cooling and increases warming;
- Sweet tastes make substances feel more viscous, on the other hand sour makes them feel less viscous;
- Sensitivity to any tastants is highest when at normal temperature (between 22-37ºC);
- Heated substances usually have lower viscosity and allow not only faster flavour release but facilitate stimulation of taste buds. That is why warm food tastes stronger, especially in cooked meats;
- Increasing the viscosity of a substance reduces perception via retronasal olfaction;
- Heating substances increases volatility, therefore stimulates and allows retronasal olfaction to be stronger;
- Irritant substances delivered together with odour, suppress perception of flavour.

1.3.4. Flavour and Sight

The influence of these factors above are natural and we seem to be consciously aware of them, others such as the sense of sight we are not so aware of – although today we hear the expression "we eat with our eyes" a lot. We are, as human beings, very dependent of the sense of sight, we have been developing it since our very own existence and to prove how much we depend on it, at the Faculty of Oenology at the University of Bordeaux, an experiment with professional wine tasters– who have their sense of smell highly developed – was conducted. They tasted a white wine blindfolded and could easily identify the tropical and citrus notes in it, however when the same white wine was coloured red with odourless dye and the same subjects tasted it with their eyes opened they described it as having wild berries flavour (Morrot, 2001; This, 2006; Prescott, 2008).

Theories as the Rubber hand illusion (RHI) suggest we perceive out-of-body part as an extension of our own if enough similar to it (Twilley, 2014). The experiment conducted to show it consisted in having subject's hand inside a see-through box, however the hand they could see was in fact a fake rubber hand, when it was poked participants would feel the touch as on their own hand, Activity in the brain was observed in fMRI images regarding areas responsible for touch, it concludes sight is part of multisensory integration (Tsakiris & Haggard, 2005).

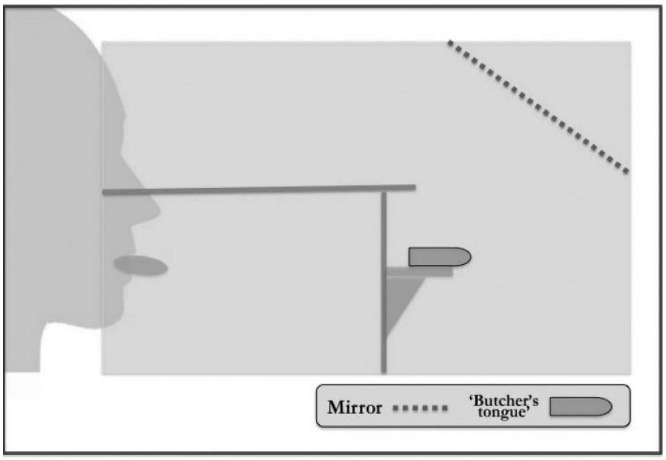


Figure 18 – Butcher's tongue experiment, box-layout. https://scontent-b-lhr.xx.fbcdn.net/hphotos-xap1/t31.0-8/10648464_525305474271034_2951288169232712236_o.jpg

An experiment based on the RHI in which tactile simulation referred to an artificial out-of-body tongue, consisted in having participants' tongue in a box with a mirror reflecting the fake tongue (Figure 18). On average, the first experiment showed participants agreed to feel they had been touched in their tongue when they saw the fake one being touched, demonstrating visual capture. When external tongue was pointed with a laser beam a significant portion of participants reported they felt thermal stimulation on their tongue (Michel, Velasco, Salgado-Montejo, & Spence, 2014). Further experiments, however not with significant number of participants, consisted in showing them a lemon, touching the lemon with a Q-tip and then touching the fake tongue, at the same time their own was touched with Q-tip that was just wet with water. Participants reported they felt sour sensation (Twilley, 2014).

The results demonstrate that the multisensory integration feeling of visual, tactile and expectation which is proved in the RHI can be extended to the tongue (Michel, et al., 2014).

These facts are enough proof that the sense of sight is part of the integration of flavour perception, thus contributing to the multisensory experience (Verhagen & Engelen, 2006).

1.3.5. Flavour and Language

As other inputs sight of food becomes, through learning, associated in the OFC together with its taste, odour, flavour and texture. Although sight is one of the most affective senses in our interpretation of food deliciousness (Michel, et al., 2014) other factors affect it, for instance a verbal or written description of what we are eating, these and other too modulate our representation of food in the OFC (Brochet & Dubourdieu, 2001; Prescott, 2008).

The reason why language influences our flavour perception is because the area of the brain in which it is developed (frontal area) is closely connected to the OFC and both are in an area essential for human consciousness and logical thinking (Li, et al., 2010).

Trying to prove it, in an experiment in which isovalveric acid was labelled "cheese" and given to test subjects to smell, it was described as pleasant and activated parts on the OFC that represents pleasure of smell. The same compound was labelled as "body" odour and given to the same test subjects, this time it was described as unpleasant and produced less activity in the OFC (Beauchamp, 2008).

We developed language and as human beings our lives are influenced by it every day, therefore language is part of what makes flavour (Shepherd, 2013).

1.3.6. Flavour and Sound

There has been a huge investment on research in this area, the influence sound has in our perception and its modulating features in taste (Knoferle & Spence, 2012). Any component in modernist restaurants is not there by chance, light frequency, crockery and furniture are some examples, and sound is always in the background and what kind of music to play is now thought carefully depending on what sensation the chef wants to give for his dish (Spence, 2012; Fleming, 2014).

It was proved that the sound we hear as we eat highly influences our perception (Spence & Deroy, 2013) – Subjects were given crisps to eat, later they put head phones and a microphone connected to them, as they eat they would hear their own sound, crisps were perceived not only as crispier but fresher as well and if the overall sound was boosted or just the high-frequency of the components of the crisp-biting sound (above 2000 hertz) were even more boosted (Woods, et al., 2011).

This shows how important sound is to our perception of crispy and crunchy foods such as crisps, cereals, biscuits and vegetables (Auvray & Spence, 2008), no wonder why in the 80's Kellogg's tried to trademark the sound of the crackling of their cornflakes. And it goes deeper, the package of cereals and crisps are strangely noisy, this was developed to create, as mentioned before, context (Knoferle & Spence, 2012).

An experiment conducted by Charles Spence and Heston Blumenthal with oysters showed that sound context is one of the main pieces to congruent perceptions although not the only one. Subjects were given identical samples of oyster, they tasted it hearing farm sounds (sheep and chickens mostly) and sea sound (the waves and seagulls) they perceived the oyster saltier and fresher hearing the sea sounds (Spence, 2008). Another experiment involving bacon ice cream showed that we may enhance a specific flavour using sound as well, subjects were given the same sample of bacon ice cream and heard to farm sounds or the sound of sizzling bacon, the bacon flavour was accentuated with the second one (Spence, 2009).

Having understood the role of multisensory perception, big industrial brands started using sensory influences on consumers, even though they are not aware of them (Knoferle & Spence, 2012). Wine cellars and shops started playing classical music rather than pop because it encourages costumers to buy higher-priced bottles, the classical music creates a context of high standards and finesse (as it is perceived by the general public). For restaurants or bars, it was discovered that just by playing fast loud music may increase the number of sips costumer take, shortening the time of drinking one drink and probably buy more (Spence, 2012).

Another experiment was designated to investigate the consequences of manipulating low and high pitch as background sound in an auditory and the influence of stimuli it has on the taste of food. The subjects were asked to evaluate pieces of cinder toffee while listening to the designated soundtracks presented in random order. The low pitch track was designated to be more cross-modal congruent with a bitter taste and the subjects could feel coffee notes in it, in the other hand the higher pitch sounds made the participants feel the same toffee more congruent to a sweet taste (Crisinel, et al., 2012).

Further studies developed and implemented an algorithm that showed different complex music, such as fragments of classic popular songs can characterize each taste. Participants were able to decode a specific taste to each of the fragmented songs (Mesz, Sigman, & Trevisan, 2012).

A study published in 2011 found that loud back ground noises suppress saltiness, sweetness and overall enjoyment of food, that is why airplane passengers seem to have such a hard time with meals during the flight, Spence pointed out in an interview: “Have you ever noticed how many people ask for a bloody mary or tomato juice from the drinks trolley on airplanes? The air stewards have, and when you ask the people who order, they tell you that they rarely order such a drink at any other time.” He believes this happens because umami taste may be immune to noise suppression, if his hypothesis is proved this may be a large step for making flight meals enjoyable, they should concentrate in ingredients full of umami like tomatoes, mushrooms, parmesan and cured meats (Woods, et al., 2011; Fleming, 2014).

Although most people do not realize it, sound plays a very important role in our perception of food and flavour perception (Auvray & Spence, 2008).

1.4. The Role of the Brain

The human brain is an ever fascinating object not meant to be fully understood in the near future, in all its complexity and amazingness it is responsible for everything that happens in the life of a human being, it is in the brain that lives our consciousness, pleasures, pains, emotions, dreams, memories, ambitions and of course when the commands for every physiological phenomena which occurs in our body. Understanding how the brain works might give chefs a new path to walk leading to brand new eating experiences and that is why it is so important to consider science in every dish created (Blake, 2008).

Our brain is composed of “grey matter” which is no less than billions of neurons, they are able to transmit and process information (This, 2006). A new-born’s brain has more than one hundred billion neurons and a regeneration rate of one which means the same amount of new neurons are formed as fast as they are dying. This is one of the differences between an infant’s brain and adult’s one which regenerates slower, nevertheless they will continue both having more than the one hundred billion mark.

The factor that changes everything is the ability of the brain to create connections between neurons, this connections reach its formation peak at the first two years of life and continue to develop throughout the rest of it. These interconnections allow neuron communication to be highly effective as one neuron can be connected to thousands more and through different sensory areas, this means that one neuron from sight responsible area of the brain can be connected to hundreds in smell, and emotion, and touch, and sound, and so on, it continues happening as long as our body keeps being stimulated throughout our life (Blake, 2008; Shepherd, 2013).

It is this interconnection capacity that allows multisensory perception exist and although it is understood by just a few curious chefs, as discussed before it is the most important factor when referring to flavour perception (Verhagen & Engelen, 2006).

1.4.1. How it Develops Tasting Preferences

Although being a helpless being that only eats and sleeps, a new born is already developing this kind of connections and moulding its self, skills and prejudices of life are now sinking in the grey matter, all this because of outside inputs and the more the better. Even before we are born we are developing our preferences and other main abilities of adulthood, by the eleventh week after conception we already have an olfactory epithelium which is able to detect odours and however still unborn a baby can breathe its mother’s amniotic fluids full of flavour molecules of what she has been eating, when the baby is born it will already have a structured natural idea of what it enjoys eating or not.

Trying to prove with this theory, a study conducted at Monell Chemical Senses Center explored how first foods taken during infanthood affect later taste preferences (Beauchamp, 2008; Prescott, 2008). Three groups of infants were bottled-fed with different formulas of milk

(milk based, soya based and from hydrolysed proteins). At the age of four, tests to determine taste preferences were taken, they were given three different apple juices, milk fed children preferred the untreated juice while soya fed liked the one which had naringin (molecule that gives bitter taste to grapefruit) and the hydrolysate fed children preferred juice that had been acidified with lemon (Mennella, Griffin, & Beuchamp, 2004).

After being offered the original milk formula, soya and hydrolysate fed children proved to most likely judge the odour and taste of hydrolysate as pleasant, they were also most likely to enjoy broccoli. It was then proven that our patterns of acceptability are based on early experiences in life which means the brain grows and develops according to whatever information it perceives (Mennella, et al., 2004).

1.4.2. Flavour Preference as Learned Experience

It is important not to lose track why flavour is so important for our brain, let us remind that the brain must know what we have in our mouth to give the order either to swallow or spit it out. That is the reason why we like some food and others not, it is a natural defence mechanism which explains why new flavour usually doesn't seem delicious when we are first experiencing it, but give it 6 or 7 more tries and if the food proves itself nutritious and not poisonous for the body it may go from dislike to like in the way (This, 2007; Edwards-Stuart, 2008). It is now evident for the professional chef that care and caution is needed when changing styles of cuisine very fast, he should give time for the costumer slowly adapt to the new flavours (Blumenthal, 2008).

Our appetites and appreciation of particular foods grow out of our experiences, either we are aware of it or not. Our perception of flavour is very subjective and why we learn to like or dislike certain foods remains unclear. We all have experienced this first hand, foods we did not enjoy as children, are very appreciated as adults (Beauchamp & Mennella, 2011).

But how exactly do we learn to enjoy certain types of food? It is known for a fact that we do not have to learn as new-borns to enjoy sweetness or saltiness, or dislike bitterness (although it is possible to learn to enjoy it later in our life). These tastes perceived in the mouth seem to be innate. On the other hand flavour is much more complex, most defend it is completely learned, although others argue some of them might be innate as well. Being the components that allow us to distinguish between what we are effectively eating, onion or apples, fish or meat and so on, odours are what make food what it is and because of that they may hold the key to what we may or not enjoy (Beauchamp, 2008; Gilbert, 2008; Yarmlinsky, et al., 2009).

The process of learning what to like begins before we are even born during fetus stage, we receive information of what our mother is eating (Prescott, 2008) and later continue being stimulated by it and (as long as we do not get ill from it) we eventually enjoy the food, the flavour of that particular food is coded in our brain and banked so we know that that is enjoyable when we eat it. As we grow older and our connections in the brain get more complex, we subconsciously start making associations of a certain flavour for an ingredient and our body may already recognize its nutrients by the odour signals, if previously it was perceived that way (Gottfried, Smith, Fugg, & Dolan, 2004).

From all senses smell is the most tightly connected to emotion since it has neuro-anatomical pathways directly connected to the OFC which exchanges information with other areas of the brain processing emotion (Li, et al., 2010). And this may hold the key to answer why – as observed by scientists as Paul Rozin – when someone moves to another country, food habits of their own country is what they hold longer to, perhaps because of the fact it is so closely tied to emotion developed in different stages of their lives (Rozin & Fallon, 1984).

However it seems that not all likes and dislikes are learnt – recently studies suggest that the volatile compounds of tomato which give its characteristic tomato flavour are signals for nutritionally valuable compounds and this plays a part on our appreciation of them as we subconsciously understand them as nutritious and good for our health.

This type of associative learning referred was discovered by the Russian scientist Ivan Pavlov, he was able to demonstrate it by making dogs salivating when hearing a specific bell, the experiment consisted on each time he was about to feed them he would ring the bell, eventually they learned that sound meant food and jut by ringing the bell (even not feeding them after) they would start salivating (McLeod, 2007; Beauchamp, 2008).

Although all foods and drinks may evoke pleasure (Prescott, 2008), this fact changes with every individual and especially the cultural background (Rozin & Fallon, 1984). The fact we like or dislike a type of food as many other complex human behaviours comes from an endless variety of influences and some of them may lie in our genetic inheritance (Beauchamp & Mennella, 2011). But particularly with food there is a tight connection between what we like or not, we are able to start enjoying something we did not and in the end what makes it happen is the kind of emotion is triggered when something is being eaten (Franken, Booij, & van den Brink, 2005).

1.4.2.1. Flavour Preference and Cultural Influence

Several studies have suggested that experiences with volatile compounds have major impact on our appreciation of food. The question is whether naturally physiological facts play a role too – is the pleasure experienced from a particular aroma learnt or evolved from each individual culture? (Beauchamp, 2008; Benzi, 2008)

Several argue it is completely learnt, take for example certain cheeses which have unpleasant smell but in flavour we like them because we learn to. On top of that there is the case of in different countries some food flavours are highly appreciated and when the same flavour is out of context they spot, for instance wintergreen is used differently in many countries in the United States of America as flavour for gums and candies and in Europe in the pharmaceutical area in ointments, resulting contrasts on its acceptance, Europeans tend reject this flavour associated to food. This phenomenon may occur between closer countries, take for example the Swiss who love the taste of marmite and the French who reject it and simply do not eat it (Beauchamp, 2008; Myhrvold, et al., 2011).

Take for example a person who is used to deal with horses, give him meat and if while he is eating let him know it is horse and that will completely change his experience (This, 2006). We may conclude cultural facts also have influence on what we enjoy eating (Shepherd, 2013).

1.4.3. Satiety and Hunger

A more primitive and natural factor on food appreciation is appetite, we all feel it when we are hungry food tastes good and when we had a full course meal food feels less delicious (Yarmlinsky, et al., 2009). Appetite does more for the complexity of representation of food, scientifically it is called the “incentive motivation” it is our body capability to keep interested in a type of food for the short period we start tasting it, however after a while that particular food starts getting less and less pleasant and we get the urge to switch the flavour of what we are eating “sensory-specific satiety”, this is clearly a natural mechanism for a varied diet, these two physiological phenomena determine what we eat, how much of it and how much we enjoy it (Yeomans & Chambers, 2008).

1.4.4. Pleasure and Food - Reward System Mechanism

Pleasure felt while eating or drinking from the scientific perspective is anything but simple. The influences are many, evolutionary, neurophysiological, genetics, social, cultural and much more but what they all have in common is that they are perceived by our brain and in its all complex existence, with countless connections it is the responsible for the enjoyment of having a meal or drinks with friends (McGlone, 2008).

Pleasure is not a modern feeling, the body always has to carry its vital functions and to make sure we keep sending in what is good for us our brain generates strong feelings which make us feel good about it and rewarded. For instance the motivation to eat is between hunger (when it is accompanied by pleasure) and satiation (when the brain sends biochemical signals telling the body that eating is no longer enjoyable) (LaBar, et al., 2001; Shepherd, 2013).

The term reward mechanism refers to the structures and systems in the brain and the behaviors and emotions they control.

This reward mechanism involves areas in the brain which are responsible for our enjoyment of a particular food, whether we want or like it (Franken, et al., 2005). Some experimental studies have shown that human emotion does not result from a single part of the brain but a group of them called limbic system.

The limbic system controls emotion processes such as hormonal secretions, mood, motivation and pain/pleasure sensations and it is structured by the amygdala, cingulated gyrus, fornix, hippocampus, hypothalamus, olfactory cortex, thalamus and OFC (McGlone, 2008).

The mechanisms which regulate feeding motivation are distributed in different areas of the brain and form a great connection that shares both sensorial and motivational aspects. The reward feeling comes from a particular neurotransmitter called dopamine which is thought to be necessary for the "wanting" feelings, different from "liking" which is mediated by other chemical compounds called endorphins, known to have an effect on behaviour (McGlone, 2008; Shepherd, 2013).

Wanting (desire) and Liking (pleasure) are two different reactions but are interrelated by neurochemical systems in the brain and both associated with positive emotions such as happiness.

Receptors for endorphins can be found in several areas in the brain and they trigger pleasure by our actions such as having a great meal, eating chocolate, laughing, dancing, listening to good music and so on, the endorphins and pleasure sensation lead after to dopamine release and the following reward mechanism of desire for us to remember how good it was, in the future (Castro & Berridge, 2014).

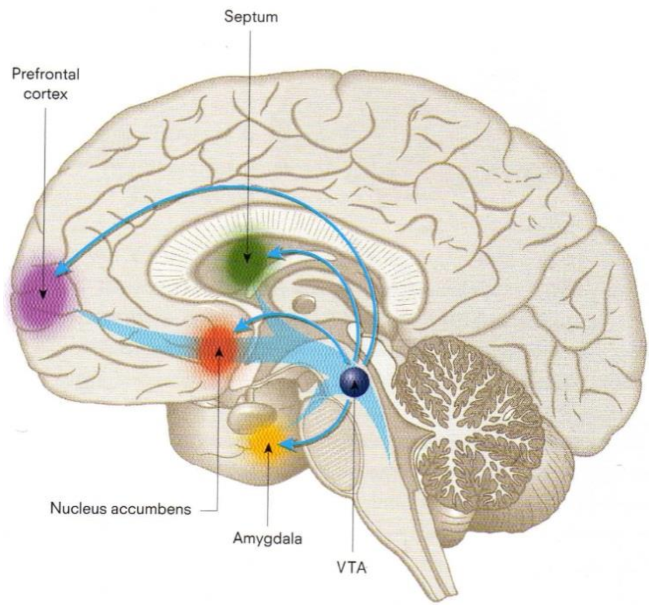


Figure 19 – Cross-section of the brain. Dopamine release to other areas involved in the reward system (McGlone, 2008).

In the center of the brain an area called the ventral tegmental area (VTA), is a group of neurons that play a very important role in reward mechanism, it receives the information from other sensory systems and updates it on how the various stimuli are satisfying our needs. The VTA then sends this information to another part of the brain called the nucleus accumbens (NA) using the chemical referred before, dopamine. It is the amount of dopamine in the NA and other areas such as the amygdala and the prefrontal cortex sent by the VTA (Figure 21) that define if our most fundamental needs as feeding are satisfied (McGlone, 2008).

Dopamine and the neurons which respond to it are the key for several brain functions associated with feelings like motivation to get out of bed or the pleasure after a good meal, it is also what some drugs – cocaine and amphetamines – trigger in our brain. Dopamine was the first neurotransmitter discovered that is associated with positive emotions and feelings as it sets all systems in the reward mechanism involved in motivation into motion. This neurotransmitter is very powerful in what it does and when artificially boosted by some drugs as cocaine or even just by too much rewarding food it causes uncontrollable desires which lead to destructive behaviour, such is the nature to addiction or obesity (Franken, et al., 2005).

A lot of the early twentieth century research focused on the inputs that we receive and how our sensory systems perceive it from the world, inputs such as sounds, sights, smells, tastes, etc. The research tried to understand how these influences were generated in the brain and which patterns were created to mirror what is happening in the external world out of our brain (Shepherd, et al., 2007; Auvray & Spence, 2008).

Recently it focused more on how much these inputs are related to each other even though being perceived in distinct sensory systems, but today we know that a consequence of this multisensory perception – which gives the brain understandable patterns of what lies outside it (Spence, 2008) – is the way we feel about it, emotionally. All kinds of emotions, depending on the subject are represented by nerve-activation reward systems of the brain and mirror the internal world, emotions do not exist in the outside world but are created individually within by each person, meaning there are no equal emotion patterns as they vary from person to person (McGlone, 2008).

1.4.5. Effect of Congruency

Rules of multisensory integration are important to discover our sensory perceptions of food (Auvray & Spence, 2008) and scientists are now studying what actually happens in our brain, neuro-imaging studies have shown that the activation in regions of the brain known for pleasure and reward (McGlone, 2008) – such as the OFC – also responds when people are given a particularly congruent combination of taste, for example when they were given a combination of red colour, sweet taste and strawberry aroma these area had high activation. By contrast when the same subject was given the same substance exchanging sweet for salty, the OFC had very little activity (Knoferle & Spence, 2012). For the professional chef these findings show how important is for a meal to have congruent matches (Blumenthal, 2008).

1.4.6. Effect of Nostalgia and Context

Smell is deeply associated with taste and flavour and from all senses is the closest to memory and emotion, all of us have a particular smell that evokes a distant past, when we were children, felt a strong emotion and it was triggered by that specific smell, nostalgia plays a key role on the final perception we have on taste. The sense of smell has special links to the amygdala which the center of emotion-processing in the brain, everyone has experienced this in first hand, when smelling food to say they know it comes from somewhere and suddenly they are filled with the emotion they had in that moment of the past, when they finally remember from where it was. The overall enjoyment of the meal will depend on the memory triggered (Verhagen & Engelen, 2006; Li, et al., 2010; Shepherd, 2013).

Such phenomena proves our likings are much more than physiological factors, they are the product of cognitive association and learning which are tightly connected with associations from the past which evoke emotional memories (Prescott, 2008).

> Take, for example, the Tonka bean (…) these black, wrinkled little beans give off a superbly heady aroma – somewhere between vanilla (the bean often provides the vanilla component of cosmetics), cloves and cut hay. More than anything else it reminds me of the rubbery moulded beach shoes that were popular in Britain when I was a kid, and I find the smell triggers lovely memories of holidays in Cornwall. A friend of mine, however, hated the taste (…) though she couldn't account for her antipathy until I told her how, for me, the Tonka bean smells of flipflops. She'd had several hefty dental

operations as a child and, she suddenly realized, the bean's rubber aroma reminded her of the mask used to administer the anaesthetic. (Blumenthal, 2008, p. 467)

As suggested above, context plays a significant part on our understanding and perception of food, we know it subconsciously. It is often said that wine does not travel but it is true that many people take vacation abroad and come back with treats for friends. When they finally get to have it again it is still very good but it is not the same as when they were on vacation (Yeomans & Chambers, 2008; Spence, 2009) – this happens because the overall sensory inputs are different, the beach is not there, the landscape is not the same, the people are different, etc., this different inputs code for a different flavour image in our orbitofrontal cortex and after that it obviously triggers a different emotion, and nostalgia is not there, satisfaction corresponds to this new image (Shepherd, et al., 2007). This explains why the sense of taste changes so much from one culture to another, different inputs, different taste perception (Auvray & Spence, 2008).

1.4.7. Effect of Expectation

It is now evident that our perception of food is not just a composition of chemical reactions, indeed there is a physiological component but it is followed by much more complex phenomena such as memory, expectation, appearance, satiety, stress, neophobia, ritual, custom, emotion, context, nostalgia (Spence, 2008).

While eating all of our senses are indirectly working, the presence or absence of the five primary tastes, the odours experienced before eating and while in the mouth, information about temperature, texture and sound contribute for the overall experience which is flavour in our brain (Auvray & Spence, 2008). This experience requires the brain to bank all the information about what happened, this is later used when eating the same thing again and because of that we have a pre-perception or expectation about what is going to happen – these processes have a lot of influence on our overall experience of food (Gottfried, et al., 2004).

As said before, during infancy our brain grows and internal connections are configured, at this stage different parts of the brain are stimulated at the same time through different sensory channels. Although this happens in parts of the brain that are more hidden, this configuration develops unique subconscious pathways if the brain is stimulated enough times and then when an event is about to happen, if the pattern starts equal to the ones imprinted in our brain we are able to foresee the result, meaning we are able to predict an almost present future, it is our expectation of what we are about to eat versus the input reality (Youngentob, et al., 2007; Beauchamp, 2008). The same phenomenon happens with learning. Take for instance the example of when we are driving home from work our already configured subconscious pathways in our brain allows us to put gears up and down when there is need to it but if we think about it we cannot recall how many gears we put along the way, however when reality does not meet expectation for instance if there is an interruption outside our pathway as an abrupt break because of a dog getting in the street it will impress our subconscious in such a way that we record that alternative pathway of braking abruptly on our way home (Prescott, 2008).

The same happens with eating and drinking and this relation between expectation and reality, conscious and subconscious activity. When we feel the same taste in food of what we were expecting we barely notice it because we are eating and enjoying it subconsciously (remember we have been recording in our brain long ago what we should or should not allow going inside our body through our mouth), to prove this just trying to remember what we ate last week for lunch may be hard to recall unless it was a highly satisfying experience (more than we are used to) or very unpleasant. We know today for a fact that food is built from several sensory dimensions other than exclusively taste, smell and texture, we might be aware of it or not for we often judge the quality but many times we are surprised by other subconscious factors (Blake, 2008; Yeomans & Chambers, 2008).

We do experience learning association with the food we eat – as referred before (Prescott, 2008)– expectations of food come different to each person because everyone had different learning curves for each flavour they taste, one of the first associations our brain does with the smell of something is its colour, because of that we start thinking what to expect of that ingredient, for example if a tomato is red we expect it to be ripe and more sweet, if green more acidic (This, 2006).

But learned association may go even further if we think about a whole meal experience, expectations from a simple bistro may mirror reality but they will not if the same meal, even at the same price was served in a fine dining restaurant. This means our personal experiences underline our expectations towards food, and pleasure of eating may be found when they are exceeded (McGlone, 2008).

An experiment conducted using salmon ice cream (which had a peach look and creaminess of ice cream) showed how our perception of taste may go from liking to disgust just by playing with flavour expectations of subjects. The same ice cream was given to two groups, but the first were told they were eating a scoop of ice cream and the second a savoury frozen mousse, the second group found the ice cream acceptable however the first group found it uneatable, some saying it was the worst thing they had ever eaten. This shows that the expectation of a sweet, fruity flavour generated by the peach colour contrasted strongly with the actual experience of a salty fish taste, as for the group who were told they were eating frozen savoury mousse they had already brought the memories that were congruent and got in the same context as what they were having and making the experience enjoyable (Yeomans & Chambers, 2008). Most of our experience of flavour depends on our expectation of it, if someone tries to eat blindfolded they will have a much less enjoyable meal, because not all the inputs are getting in and there is not image to compare to. Pleasure experienced in the act of eating is very important and can be maximized by generating congruent and nostalgic expectations about the food that is being consumed (Verhagen & Engelen, 2006; Shepherd, 2013).

1.4.8. Multisensory Integration – the Flavour System

As stated before, the human brain is able to connect several senses and emotions together and create what we call flavour. This phenomenon is known to be different from most other animals as they are naturally prepared to perceive orthonasal smell while humans mainly perceive smell through retronasal olfaction (Auvray & Spence, 2008; Shepherd, 2013). Humans also have bigger brains with more interconnections between the different specialized areas, we have language as well entering in the multisensory perception of food and complex sensations. These factors allow flavour to be built as an image in our brain. This is mainly processed in areas specialized in logic thinking, therefore this multisensory integration (Figure 19) which our brain recognizes as one sense – flavour – is unique to humans (Shepherd, 2006).

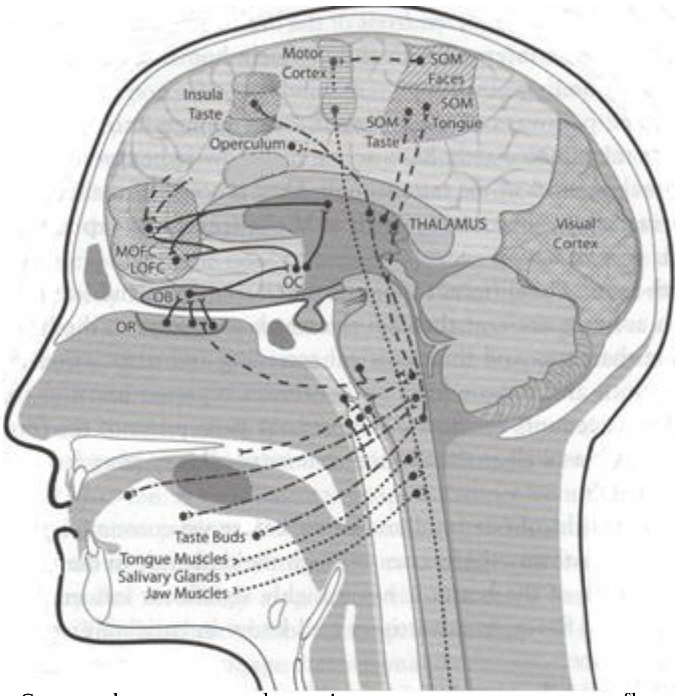


Figure 20 – Flavour System, how sense and emotion areas connect to create flavour. MOFC –Medial Orbitofrontal Cortex; LOFC – Lateral Orbitofrontal Cortex; OB – Olfactory Bulb; OR – Olfactory Receptor Cells; OC – Olfactory Cortex; SOM – Somatosensory System (Shepherd, 2013).

In summary multisensory integration begins with the five basic senses (Knoferle & Spence, 2012; Shepherd, 2013):

- Smell – has direct pathways to the olfactory cortex in the limbic system, which allows the brain to access memory and compare it to the smell image of the input. Further the information is passed to the orbitofrontal cortex and exchanged with emotion related areas in the brain.
- Taste – the input passes through emotion areas before reaching its own processing area.
- Touch – the input passes through the thalamus before reaching its sense area. In the mouth somatosensory cells are very sensitive and they trigger an illusion that flavour is perceived in it.
- Sight – It is the first input one has before eating, this creates expectation and highly influences the rest of the integration.
- Sound – It is part of the integration and influences multisensory perception, it acts as one is eating.

In the multisensory integration, when two or more senses are processed together in the brain, it follows with an emotion or sensation which will define the behaviour towards what one is eating (Xu et al. 2000; Beauchamp, 2008; Yeomans et al., 2008; Shepherd, 2013):

- Emotion – all animals have emotion processing areas, in humans this area is significantly developed in size and it means emotion in humans extends to flavour perception and defines our appreciation of food.
- Nostalgia and Context – there are several memory regions in the human brain to engage with flavour, these sensations will contribute to different types of emotion.
- Congruency – liking or disliking food is, in most cases, a learned experience. Our brain compares flavour images, some are more congruent than others.
- Expectation – the human brain is capable of predicting a near future because of its ability of making decisions and balance the complex effects of one’s choices. This affects congruency and is usually mediated by sight and language.

The multisensory integration phenomenon can be explained with a flow chart as it is shown in Figure 21.

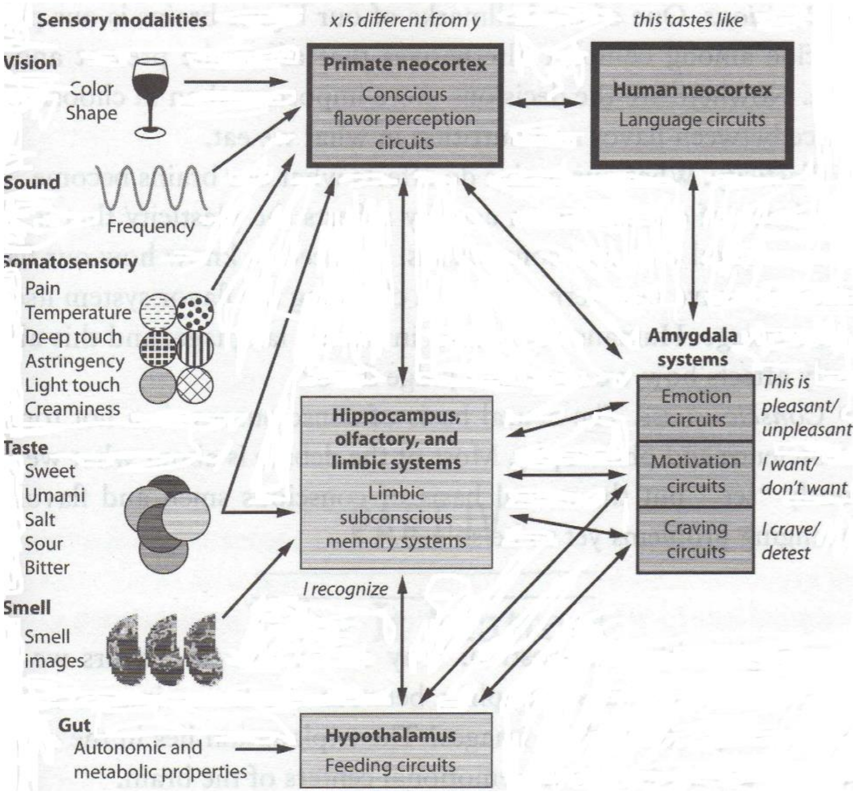


Figure 21 – Flavour System shown as a diagram (Shepherd, 2013).

The diagram above shows how complex flavour perception is. And on top of that, very little information is taken for granted until today, as it is just starting to be explored by experts. We are now starting to understand more about how our brain processes flavour and this information can be taken to the advantage of the professional chef.

1.5. On Job Training

On the job training is provided from most modern companies, it can be understood as a training that is taken at the workplace by either a trainee (intern) or apprentice (new employee). Although some defend it is beneficial to both interns and company, there are some that do not provide proper on the job training to its employees (Wood, 2004).

For a professional chef, this type of training is of great importance, until some decades ago it was the only way of becoming a chef, under the training of others. Nowadays, cooking schools provide most of the tools needed for an easier and more contextualized on the job training for students (Myhrvold, et al., 2011).

Some defend that there are several benefits – both for the company and the intern – when proper on the job training is given by the company:

- Higher performance of individuals and teams;

- More positive attitude towards work;
- Higher motivation;
- Empowerment of employees and interns (creating job offers);
- It is a good way to learn;
- Creates independence of apprentices both as learners and workers, leading to self-directed learners;
- Creates opportunities to learn in a more naturalistic manner (already adapting to the working rhythm).

However there are other facts that are part of or a result of on the job training that may not be as beneficial as the ones referred before:

- Training in isolation may lead to demotivation;
- Competing workloads may result in the intern to give up;
- Lack of theoretical knowledge compromises the company's credibility and the intern's moral;
- Most employees are not trainers and may not be good at passing knowledge to interns;
- Financial loss for both the company and intern.

As suggested above, training proves to be beneficial to both individuals and teams. The overall of the training experience will depend on the company's capability of providing proper on the job training: more already well trained staff results in higher chances of well training an intern, he will therefore, have more opportunities of contributing to the company with higher standards of his work, at a rhythm that he will be used to.

However if no proper on the job training is provided, the company will lose time and money as well as the intern. On the job training should be taken after the intern has some theoretical background to take the internship experience to his advantage (Wood & Aguinis, 2009).

Chapter II – Experimental Study

Given the title of the main research subject "Effect of nostalgia triggered by sound – from the *Sound of the Sea* dish – on flavour perception", it was assumed the best way to present this dissertation would be to make clear how to learn/improve new skills, while combining all knowledge gathered during the master degree with the on job training. Therefore an internship at the Fat Duck experimental kitchen was discussed (see Appendix 1) – The Fat Duck is well known in the restaurant business for its scientific approach to cooking and the multisensory perception triggered by their tasting menu.

Research and tasting were incorporated in the internship, working methods and philosophy at the Fat Duck Experimental Kitchen helped to a better understanding of the subject in order to provide a better sensory experience to the costumer during dining experience.

The following intends to help the reader understand the concept behind the Fat Duck, which is an important issue related to the experimental study itself. This chapter has two major sections: one introducing the Fat Duck group/Heston Blumenthal's story and approach to cooking and leads to the second part which regards the description of internship routine, methods and the sensory tasting, thought to support and prove the subject of this dissertation.

2.1. Scope of Study

Although the main study subject refers to gastronomy, other collateral subjects related to technology, physics, bio-chemistry and neurology had to be explored. All being connected to the main subject they have just recently started to be studied by experts.

Gastronomy aspects related to cooking and everything related to it are approached as well as their global appreciation and influences. But more important of all gastronomy is directly related to all the other subjects and that is what connects everything in this dissertation.

Technology refers to processes, use of ingredients, concepts and equipment used to achieve intended results.

Physics concerns the study in the kitchen as far as it is related to products and simple processes such as reactions between product and solutions, physical and functional properties of single ingredients.

In bio-chemistry the chemical and physiological reactions in our body which allow taste and flavour perception to happen are studied.

Neurological focus on how our brain reacts to stimuli from taste and flavour on its perception, how multisensory perception works and how it triggers emotion affecting perceived tastes and flavours.

Specific subject of the study refers to the role of nostalgia, which is triggered by sound during a fine dining experience.

2.2. Investigation Objectives

It is intended to evaluate how the final perception of taste is affected when a costumer feels nostalgic about what he is eating. The results will be accounted for from a tasting assay in order to demonstrate the importance of multisensory perception during dining experience.

Having that in mind, the main objective of this study is to understand how nostalgia triggered by sound, from the *Sound of the Sea* dish affects the final perception of taste.

Specific objectives of this study also help to get better understanding on the subject:

- Review and resume literature related to the study.
- Record valuable information about routine in the Experimental Kitchen.
- Discussion of normal procedures at the Experimental Kitchen and implementation of knowledge acquired during master's degree.
- Organization of a sensory analysis having in mind a base recipe of the dish *Sound of the Sea*, untrained tasters panel and nostalgia factor triggered by sound.
- Analysis and processing of the outcome resulting from the sensory analysis.
- Discussion of what factors allow chefs to understand and control better the dining experience through nostalgia triggered by sound.

2.3. Methodology

The starting question – does nostalgia, when triggered by sound, play a significant role on the final perception of taste? – was not only the starting point of this study but also continued as reference throughout its development.

After having the subject decided, reading about it led to a better understanding, however meeting with the university professor was needed. In October, at Estoril Higher Institute for Tourism and Hotel Studies (EHITHS), Estoril, Portugal a plan was outlined to guide, trace deadlines and help with the bibliography's review organization.

This meeting also led to a basic understanding of which fields to explore without losing trace of the starting question. Several study basics were set and the reading period started.

Literature Review began right after the first meeting and went on from October 2013 to February 2014 – half time through internship. This allowed to start preparing a base analysis model for further investigation of the subject and decide which stimuli would be used as regards the tasting in order to get proper results and as little outside influences as possible. During reading period from January 2014 to end of February 2014 a meeting was set up at the Fat Duck restaurant, Bray, UK with Dr. Charles Spence who helped fully understand which parameters complied best for the study.

From early January 2014 to half way April 2014 observation and data recording took place, both from the internship and the tasting with nine people. It happened gradually, being an on job training at the Fat Duck restaurant.

Later, from May 2014 to June 2014 new literature gathered during the internship was reviewed and the data resulting from the tasting assay were accounted for.

Lastly until October 2014 all the data recorded and literature reviewed allowed to answer the starting question – Effect of nostalgia triggered by sound from the *Sound of the Sea dish*, on taste final perception – and develop a base which allows professional chefs to understand better multisensory perception and take it to their advantage.

2.4. Internship

A very Important part of this dissertation took place at the Fat Duck restaurant, Bray, UK from January 8th to April 4th 2014, the main objective was to learn on job, discuss the companies' policy and methodology and improve knowledge gathered during the Master in Innovation in Culinary Arts and Sciences (MICAS) from the Estoril Higher Institute for Tourism and Hotel Studies, Estoril, Portugal (see Appendix 1).

2.4.1. The Fat Duck Group

Heston Blumenthal is the mastermind who received an Honorary Doctor of Science degree awarded by Reading University in recognition for his unique scientific approach to food and long-standing relationship with the University's School of Food Biosciences – and is behind one of the most celebrated restaurants in the whole word, nowadays with a bigger empire and a total of six Michelin stars (see Appendix 2) from all of his projects. The Fat Duck awarded with three Michelin stars was considered best restaurant in the world by the World's 50 Best Restaurants by S.Pellegrino & Acqua Panna (see Appendix 3) in 2005. Dinner by Heston

Blumenthal is another project with high standards, having just received its second Michelin star and ranking 5th place in this year 50 world's best restaurants by S.Pellegrino & Acqua Panna.

The Hinds Head is a Michelin starred pub near to its younger brother The Crown at Bray, also a pub which serves simpler but not less delicious food.

Apart from the restaurant business there is Heston Blumenthal brand signature which features a lot of professional and domestic kitchen equipment. Heston Blumenthal also has a food brand in Waitrose (UK) and Coles (Australia) supermarkets (Duck, Awards, 2014).

2.4.2. Heston Blumenthal

"I was sixteen when my parents took me to the three-star Michelin restaurant L'Oustau de Baumanière in Provence in 1982. It really was a *coup de foudre* – love at first sight. I fell in love with cooking and the idea of being chef." (Blumenthal, 2008, p. 22) – As expected everything was really amazing, nothing like any of them had ever experienced. Not only the food was amazing but the night and all surroundings, the delightful smell in the air, the sounds coming together and the almost like theatre performance of the waiters carving lamb at the table and pouring lobster sauce unto soufflés. It was then that he started reading every culinary book he could, more fascinated than the day before (Blumenthal, 2008).

At the time he bought famous restaurant guides, among them the Michelin guide to search for those forks and stars awarded to high quality restaurants names. He would then look for their Chef's and buy his/her books, learning their cuisine philosophy and famous dishes (Blumenthal, 2008).

At the age of eighteen he decided to start looking for a job as an apprentice, he sent several letters applying for jobs and one day good news arrived, one week probation at one of the best restaurants in the UK. It did not go as he expected, probably for his inexperience just like many young chefs nowadays who come from school and think they are ready for the big demanding tasks in a kitchen. A huge mountain of green beans was waiting for him to be prepared as he walked in (curiously this was not the only time green beans played an important role in his career) and after that, boiled potatoes to be peeled, fish to be gutted, and so on – the type of work usually given to whoever is starting a career. Every good and responsible chef would not even think of giving important tasks to young apprentices, a restaurant has to be like a well-oiled machine and each chef has his own task and has to master it for the machine to work properly, after all every restaurant stars each day from zero, just like any machine reboots to start all over (Blumenthal, 2008).

Having started his own apprenticeship period, by reading and trying to figure out the reasons why something had gone wrong when trying dishes – Heston, just like many others was not sure the traditional apprenticeship path was right for him, maybe because he was afraid of finding out he was scared of the commitment and would he be up to it? He would for sure not spend a lot of time, in a high quality restaurant to follow his career because the Chef says so. Heston followed the path of the self-taught man (Blumenthal, 2008).

He had worked in a variety of different jobs – photocopier salesman, debt collector and credit controller – but never losing sight of cooking. As time passed the dream of becoming a chef was looking more and more realistic, he had enough knowledge to understand most of kitchen techniques and although he only spent one week at that probation site he made friends and now had access to professional suppliers and a whole new type of ingredients for his trials (Blumenthal, 2008).

Every summer for one decade he would spend some time in France (considered the land where cuisine was born) from one side to the other visiting restaurants, suppliers and wine estates in order to learn as much as possible about gastronomy and banking flavour memories for the future. In the end it was his car which fed them, he and his wife had to sell the car to maintain the usual trip to France – but it was seen as an investment. This was his self-taught culinary apprenticeship way apart from some weeks in a couple of professional kitchen (Blumenthal, 2008).

2.4.3. Discovering New Ways of Thinking Cuisine

Reading and studying played a very important role in Heston's education, when he was still collecting all sorts of information and there was a particular book which changed his mind about cooking; it made him look into cuisine in a completely different way – the section discussing the physical properties of meat, stated:

> We do know for a fact that, whether done early or late, searing does not seal, but it does brown: it won't prevent flavour from escaping, but it creates flavour via the complex browning reactions. And because it has become a matter of taste, today's experts have come to different conclusions on the matter. Some recommend searing all but the toughest of meats, others are devotees of the constant method. So there is good reason to sear meat, but it has nothing to do with nutrition or juiciness. (McGee, 1986, pp. 115-116)

The book was On Food and Cooking by Harold McGee, it made Heston's curiosity grow stronger and showed him the benefits of not taking anything for granted, a new way of thinking cuisine through a scientific approach started, the path of breaking some untouchable rules of cooking, the precise questioning and testing culinary ideas alongside some more traditional kitchen skills (Blumenthal, 2008).

- Mushrooms should never be washed;
- Salting meat before cooking prevents browning;
- Tenderness of meat is affected by the way in which is carved;
- Cooking green vegetables with a lid on will dull their colour;
- Salt must be added to pulses at the end of cooking;
- An egg yolk can only emulsify one cup of oil;
- As meat cooks the juices move towards the center;
- Storing tomatoes in the refrigerator ruins their flavour;
- Fish is ready when specks of white albumen appear on its surface;
- Flour must always be sieved (Blumenthal, 2008).

Even nowadays the common chef is used to these "kitchen laws" and most of them still do it without questioning, it is the law after all. But are we not limiting the ingredients full potential living by these words? Heston was already trying and questioning most things, this was the moment he understood the importance of science in the kitchen –but do not take this the wrong way, science in the kitchen is not only about the expensive and extremely complicated laboratory equipment we see in today's modernist kitchens, science is also about how to make a perfect poached egg and reach the consistency wanted, it is knowing that "Searing=Sealing is false" (Blumenthal, 2008, p. 38) because if you weight a steak, sear it and then weight it again it will be lighter, put it on the pan one more time and it will lose even more, the sound we hear when searing is water evaporating from that piece of meat. If we think a bit of it we can tell what nonsense this sentence is, it would be impossible to have a well-done steak because searing would prevent juices to come out as well as it would not be possible to have a juicy and tender piece of poached meat because the lack of sealing would allow the juices to come out (Blumenthal, 2008).

Science, questioning, writing and evaluating different results became of major importance for Heston's cooking, as it was said before some classics remain the same of course, but science is merely a tool to work with, almost as essential has a chef's knife. In the end deliciousness is the most important thing in cooking, everything was tasted again and again, it is the costumer who makes the food delicious after all (Blumenthal, 2008).

2.4.4. The Fat Duck

After almost ten years studying, in 1995 Heston bought a 450 year old pub in Bray Village. Small with a packed kitchen, only one door and no fancy views, the toilets were outside and had reputation for being the hotspot of every drinker banned from the other pubs in the area, obviously not ideal for a restaurant but at the time it was all he could afford (Blumenthal, 2008).

The project, like many others started very humble and not thinking of any stars. The concept was a simple bistro serving French classics. At the start he it could barely make ends meet until the of the month, Heston's inexperience in actually running a restaurant and the limited funds meant full dedication – twenty hours a day in that tiny kitchen, snatching fifteen minutes sleep curled up on a pile of dirty tea towels. He states that there was even a time he noticed he was preparing some pieces of fish and suddenly they were cut into strips and squares, he had fallen asleep and his body continued working (Blumenthal, 2008).

Having invested all his savings in that business did not give him chance to hire highly qualified staff. They started with people in the kitchen who were not chefs and front of house doing their job for the first time – The truth is many of them were dedicated and learned fast but it is just not the same, work takes longer and the techniques must be simpler in order to be done properly (Blumenthal, 2008).

Heston had plenty of difficulties, staff was always changing but after those first two dark years, he had already managed to hire some talented professionals and the staff was getting better (Blumenthal, 2008).

They were starting to reach some of the food guides for their unusual approach – instead of finding it strange and off the picture people were enjoying and trying to understand the secrets behind his cooking. There were no secrets, only years of study and many more of trials, again and again (Blumenthal, 2008).

In that year of 1997 the Fat Duck was no longer the classic bistro as it started to be, it had developed identity and the trend was catching on fast. There were rumours that year they would hit the holy book of fine dining, the Michelin Guide – it did not happen though (Blumenthal, 2008).

With the quality of the staff rising, there was more time to experiment and to waste in better quality mise-en-place (put things into place, before cooking). Work did not slow down for one minute, they were always trying to go forward and pushing the boundaries of what they had already done, it did not take long until he developed the first dish of his own, his first signature dish – *Crab biscuit with Roast Fois-Gras*, which features in today's tasting menu (see Appendix 4) although very improved. It came out after trying endless times with different types of crab to get the right flavour, curiously it was not the most expensive delicacy which gave the best result but an ordinary type of crab which yielded and intense, almost nutty flavour – it was roasted until brown and then boiled in the best stock they found from their experiments, which turned out to be water. It would then boil for two hours, stand for one more and after reduced to almost only two spoonful of it, the result has a brothy, meaty umami taste. The biscuit would be served with roasted Fois-Gras, Kombu seaweed and oyster vinaigrette – the kind of combination people were still not used in the late 1990's but it caught the attention of the public (Blumenthal, 2008).

The Fat Duck was getting known among the culinary world, which meant better staff wanted to work with them and the ridiculous amount of working hours now seemed worth the sacrifice. It was in 1998 The Fat Duck received its first Michelin Star (Blumenthal, 2008).

2.4.5. Revolutionary Partnership

Although Harold McGee's Book changed the way Heston's approach on cooking it did not revolutionized neither his career nor the Fat Duck (Blumenthal, 2008).

Nevertheless, science was getting more and more into the kitchen and did not always happen for the same reasons, sometimes it was fired out of curiosity and others by necessity. Even after the first refurbishment in 1995 the kitchen was not ideal to work in, for instance the house type gas pipes (thin ones) were not changed and it meant low heating power when trying to boil something – it just takes ages to do it and whenever the team had to blanch de green beans for service they had to do it in smaller but more bathes in order to be able to preserve the greenness and texture (Blumenthal, 2008). Blanching is a simple and handful technique used to preserve the organoleptic quality of vegetables, it consists in cooking them for a short time period (it changes with the type of vegetable) and then put in ice water to stop the cooking process, some enzymes responsible for degradation and natural browning of the cellular walls denature so the vegetable not only lasts longer but, has now shorter cooking time and its colour is enhanced (McGee, 2004). The fact that they had to do so many batches meant they had to stop every ten minutes, take the beans into water and ice and do it all over again For those who work in a restaurant kitchen see clearly how this makes such trouble to other mise-en-place – for those who do not, in a professional kitchen timing is the most precious thing, a chef needs his time to do his chores and it is common skipping staff lunch or dinner now and then to be able to finish on time for service meaning every minute is extremely valuable, having to leave a task stand by several times to transfer the beans made something else fall behind (Blumenthal, 2008).

Battling with green beans once again and trying to overcome this, it eventually led Heston to another dramatic discover – adding salt to the water while blanching does not necessarily fix the colour of green vegetables (McGee, 1986). He did not understand exactly the reason why and did not have the time either to go deep into these matters, it became obvious he needed to find someone who would translate science to a simpler language, one which chefs could understand (Blumenthal, 2008).

His first choice was, of course, Harold McGee and so he sent an email explaining the restaurant's concept but destiny did not want the two to meet, not until later in an airport in Italy. Casting around for alternatives, he contacted Hervé This who explored several scientific aspects of food and was as enthusiast sharing some new culinary ideas such as Chocolate Chantilly a confection that looks and tastes like chocolate flavoured whipped cream but contains no cream at all, demystifying that chocolate and water do not mix, the result was a clearer and purer taste, and had an article explaining how mayonnaise was able to emulsify and stay stable for a long time because of the protein lecithin which coats the fats particles and prevents them to get together again (Kurti & This, 1994). However, Heston knew he needed someone closer to home for some real hands-on the subject (Blumenthal, 2008).

He tried contacting Nicholas Kurti whose curriculum referred he worked on the atom bomb during the Second World War and was a professor of physics at Oxford. Kurti had already made some papers in which he manifested his interest on cooking, he introduced the benefits of using certain enzymes to tenderize meat, cooking meat at low temperatures and the use of the microwave, and it was indeed with Nicholas Kurti which some of today's modernist techniques started. Unfortunately Nicholas had just died a few months before, in November 1998 (Blumenthal, 2008).

Heston eventually reached Dr. Peter Barham from Bristol University, called him and explained his situation about the beans not changing in texture or colour by the addition of salt in the water. "Eureka! - He replied. At last, a chef who understands" (Heston, 2008, p. 68). He then explained that it was down to calcium content, which is especially high in hard water. Chlorophyll present in green vegetables is held by magnesium and when calcium is present in the solution exchanges with magnesium and with it goes Chlorophyll (Figure 22). On top of it there is the fact that in hard water the cooking time is higher making vegetables more likely to lose their colour (Blumenthal, 2008). Chlorophyll does not only change with calcium content, it is affected by heat as well by acidic and alkaline solutions, between 66-77ºC an enzyme called chlorophyllase breaks its long carbon-hydrogen tail (fat like chain – which makes chlorophyll fat soluble), without its tail the pigment is now water soluble and rapidly dissolves into the water where it is being cooked, leaving the vegetable and the few chlorophyll which remains loses magnesium to hydrogen if the solution is slightly acidic (McGee, 2004).

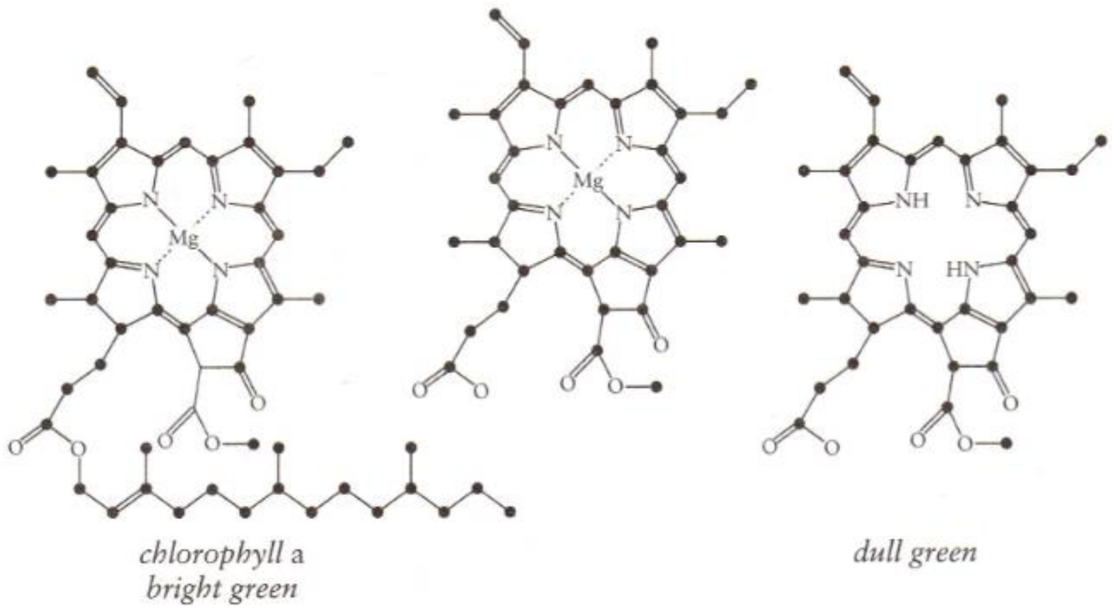


Figure 22 – Changes in chlorophyll during cooking (McGee, 2004).

Peter Barham was an enthusiast who wanted nothing else but demystify science and he could translate science in words Heston would understand. It was everything he needed (Blumenthal, 2008).

They started meeting regularly and they would discuss several things, among them they began exploring the potential of liquid nitrogen in cooking, it led later to Heston's *Nitro Poached Green Tea and Lime Mousse* which features in today's menu (although different recipe the technique is the same) – and Peter's super-speedy ice cream which features now in the Guinness Book of Records. In Peter's lab Heston could use the rotary evaporator (see Appendix 5) to produce flavour of almost anything, they found out that at different temperatures under vacuum different volatile molecules evaporate, in a specific case they were able to produce garlic flavoured water but very gentle without that pungency of fresh chopped garlic, it was really a marvellous taste of the smell of raw garlic because at that temperature only a group of volatile molecules evaporated, leaving behind the pungent ones (Blumenthal, 2008).

Along with Heston, Peter was always bringing people together in the name of science, eventually he introduced him to Tony Blake, the vice-president of food and technology at a

Swiss flavour and aroma company named Firmenich, a partnership which later highly expanded the Fat Duck culinary universe of equipment, ingredients, techniques and ideas (Blumenthal, 2008).

Tony Blake was just as eager to find new ways of approaching cooking (in a scientific way) as Peter Barham. The day Heston met Tony he was very excited to hear what he had to say about his recently developed dish crab risotto garnished with crab ice cream. Back then the idea of a savoury ice cream was making quite a stir, in and out of the restaurant and Heston wanted to know why. The dish had already gained its own logic, first it was not obeying a simple classic law, do not add parmesan cheese to seafood, they are both very rich in umami and it means it will be over powered ruining the dish, however the team eventually found a balance between the two and the result was a massive mouthfeel. Heston wanted to add a cold garnish to the dish, the reason for crab ice cream – and he even had recently found out that he could prevent instant melting by layering between a heat resistant gel as Gellan (see Appendix 6) – but the name was not being well accepted at the time, he later discovered costumer would not only find more acceptable but less sweet if it was called frozen crab bisque for instance. These findings were more important than Heston could realized at the time, how subjective taste perception could be, despite all the ingredients or techniques (although being the main reason for appreciation) it seemed it was way more complex than that and this determined the direction of Heston's cooking, especially after receiving the third star (Blumenthal, 2008).

Tony Blake eventually invited Heston to fly to Switzerland and take part in some projects that were going on at the time and allowed him to get into the procedures of academics searching for pure knowledge. Today Firmenich is world famous and a top company not only in perfume but in the food area since they started producing fruit flavours – they had new departments related to experimentation for the food industry. People usually see this type of chemical manufactures with suspicion. The problem might not be in the inventors who work in those companies but the other industries which buy the technology and knowledge developed by them – for instance ham is made out of meat which has been minced and cooked until it completely dries out and then is injected with gum, starch and water to regain the original texture and moistness, but in this case it happens because there is interest for the industry to do it, they are now selling water as part of the product making it profitable. The same technology may be applied in restaurants just imagine injecting beef's own juices again in the meat after it is cooked in order to regain juiciness and flavour (Blumenthal, 2008).

There are other popular experiments that started in the industry business and then were worked by enlightened professional chefs, take for example the use of alginates to form gels, it was used in experiments to bind together again fruits or encapsulate drugs, and in recent years have been used by Ferran Adrià for spherification process and consists of making a sodium alginate solution and poring it with a round spoon over a calcium chloride solution, the Na^+ ions in sodium alginate (Figure 23) instantly exchange with Ca^{2+} ions in calcium chloride and the polymer becomes cross-linked (Figure 24). The result is calcium alginate a consistent polymer which was used by Ferran Adriá to encapsulate the liquid inside used as solvent (Walfaman, Schechinger, Nowick, & Pignolet, 1998).

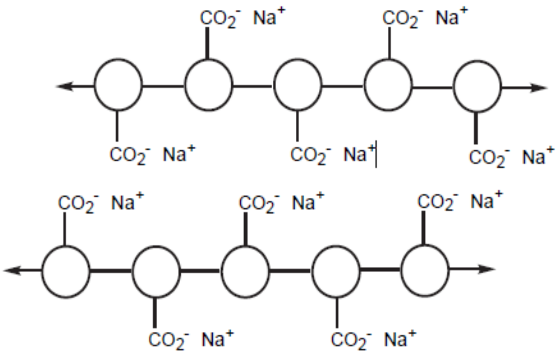


Figure 23 – Alginate polymer in NaCl solution (Walfaman, et al., 1998).

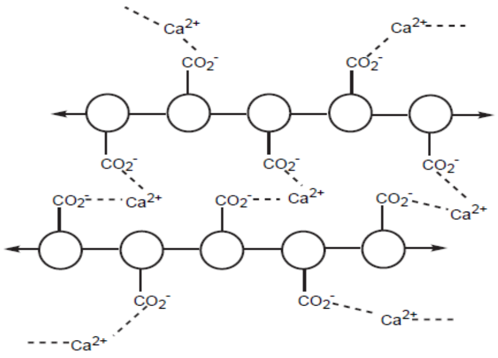


Figure 24 – Alginate polymer in $CaCl_2$ solution (Walfaman, et al., 1998).

Firmenich, being a large company and targeted to food industry has a huge body of knowledge and there are several times when scientists are not aware of the value of their discovery, it was the case of one ingredient they would use almost every day, maltodextrin was so natural to them that they did not see the side-benefits of it in restaurants. It can be used, amongst other things, to fabricate powder of almost everything for its absorption capabilities (see Appendix 6) – there were never ending possibilities (Blumenthal, 2008).

One time experimenting with liquid nitrogen and injecting carrots with asparagus oil, and asparagus with carrot oil, and eggs with smoked bacon flavour they began thinking of the importance to reaction flavours, different volatile molecules may react differently with each other, similar volatile react in harmony and opposite ones react by contrast. This could be a new way for pairing food and after discussing it with Professor Don Mottram at the Firmenich symposium Heston was starting to understand it better. Heston was even more excited to find out he was working not far from the Fat Duck in the Reading University's School of Food Biosciences, and that meant there was a lot of new technology to experiment, technology the restaurant did not have space for nor could he afford it (Blumenthal, 2008).

When developing a clear rich umami broth to go with a slightly cured mackerel at the Fat Duck Heston noticed that the richness of the broth changed according to the part of the tomato was extracted, different in peel, fresh or insides (Blumenthal, 2008). He partnered with Professor Don and after finding there was no work about it they decided to start exploring. It resulted in a paper that proved their theory, the seeds are the part of the tomato more concentrated in umami (Oruna-Concha, Methven, Blumenthal, Young, & Mottram, 2007), although many classic cookbooks prefer to discard them, Heston was ready to once again take the most out of science into his cooking, just like searing a piece of meat doesn´t seal the juices and adding salt to the water when blanching beans does not necessarily prevent colour loss (Blumenthal, 2008).

Although Firmenich was at start the place for science exploration there were other places which contributed a lot for the scientific approach at the Fat Duck and Erice Workshop on Molecular and Physical Gastronomy was one of them, Heston was invited to do a presentation and talk about his discoveries, it was there he finally met Harold McGee and other enlightening scientists who were there for the same reason, sharing their ideas about what cooking can become if chefs learn about science (Blumenthal, 2008).

2.4.6. Road Into the Stars

Not much after the birth of a culinary partnership the restaurant received its first Michelin Star, Heston's cooking had come a long way from bistro French classics and the need for a change was clear, the restaurant was refurbished and redesigned to meet much higher standards. In 2000 the place was re-opening with its first multi-course tasting menu, it offered an opportunity to present many kinds of dishes which did not fit easily into more conventional formats. The team was getting bigger and better and it meant all sorts of Heston's ideas were put in the right gastronomic setting and new and better equipment started being used such as precision cooking water-baths and rotary evaporator (see Appendix 5). After reopening with a better kitchen and a lot more conditions to work, like proper gas pipes and more cupboards to place equipment meaning more work space, the new equipment were put to test, slow-cooking water-baths were initially used to poach salmon in the water, later the team discovered better results putting the salmon in a vacuum bag and sealing it, sous-vide technique (see Appendix 7) it would not only benefit the flavour but prevent oxidation and keep a cleaner environment-Other appliances started being explored for example in slow cooking meat (see Appendix 7) . Without expecting it the restaurant was awarded the second star in 2001 (Blumenthal, 2008).

Being awarded with two Michelin stars is a dream come true for any professional chef, however it is not luster all the time. Winning the star meant even more precision in the way they cooked, hiring more qualified staff, maintain the standards very high. On top of this the Michelin star did not bring much more people to the restaurant, it is true the Fat Duck was fully booked on Saturdays and Sundays but it is throughout the week days we can see if the business is going well - economically speaking, and the dining room was rarely fully booked during the week. When in the restaurant business the owner must keep an eye on the dishes gross profit, the difference between the selling price and the ingredients cost and although they had plenty of servings during weekends it was not enough to compensate the rest of the week, this meant there was almost no cash flow by the end of the month and there were times Heston barely had enough to pay his employees (Blumenthal, 2008).

Being Chef proprietor of a restaurant is not easy, a restaurant manager looks at the numbers, a chef looks at the quality of food which is being served to guests, he had to choose a path and decided to continue searching for perfection no matter how difficult it could be (Blumenthal, 2008).

In 2004 he was invited to speak at Madrid Fusion II, a chefs' congress with many famous faces from kitchens all around the globe. They present new trends and their most considerable achievements in cooking so Heston talked about the a subject that had long fascinated him, flavour perception, along with others such as the benefits of cooking in high pressure with pressure cookers, with liquid nitrogen liquid nitrogen and bringing some laboratory equipment into the professional kitchen. When the conference ended he received a call from his restaurant manager saying they had just been awarded the third star (Blumenthal, 2008).

After cooling down from the heated news and being congratulated by many chefs at the congress he was told this was his golden ticket and there was no going back – as if they knew his anxiety and pressure for barely having enough to maintain the restaurant – later and back to Bray they started receiving calls asking for the nearest helipad, the phone rang all day long and the restaurant started to have waiting list, fully booked almost every day. In the same year the Fat duck was ranked second best restaurant in the world by S.Pellegrino & Acqua Panna, it reached the world's best the following year in 2005, second position straight until 2009 and it was third best in 2010 (Blumenthal, 2008).

2.4.7. Multisensory Perception

The third star gave Heston even more freedom and financial comfort to explore subjects that have become central parts of his approach to cooking: Multisensory perception and how the brain influences our appreciation of food. Since the late 1990s' when Heston discovered costumers actually tasted crab ice cream differently depending what it was called he got fascinated about the way we perceive flavour and how subjective it is (Blumenthal, 2008).

He eventually meat the psychologist in Dr. Charles Spence who had been for many years exploring the way our brain is influenced by different stimuli, after going to his laboratory and being a part of some of Spence´s experiments such as eating Pringles and listening to the sound of crunchy chips, resulting in sensing the Pringles were getting crunchier (Spence, 2008). Heston quickly thought of ways to bring that multisensory influence to the Fat Duck dining experience, he started giving some diners head phones, and played farm and beach sounds separately while serving oysters, and the fact is diners perceived oysters differently, the ones listening to beach sounds felt saltier and more fresh, although they were exactly the same (Blumenthal, 2008).

However it did not feel appropriate to have big headphones all the time in the restaurant, costumers are not laboratory rats he could experiment on – that is what it felt like, experiments and a restaurant can never be that. It took him three years to come with the right idea for a dish which would become *Sound of the Sea* (see Appendix 8) (Blumenthal, 2008).

At the same time he started thinking about the way nostalgia played a role in our perception and quickly he became devoted to trigger it in his dining room to costumers, he started by just having a little conversation with diners asking what their childhood memories of food were, this seemed to put them on track for the follow tasting menu they would be having. This idea became increasingly central to the dishes at the Fat Duck (Blumenthal, 2008).

Just as Crab Ice Cream on perceived saltiness, so did nostalgia, sensory cross over, the words of the waiter or even the tableware could have an effect on perceived flavour. Quickly they began trying to emphasize dishes they already had developed in the menu such as the delicate scent of Lime Grove that goes now in the *Nitro-Poached Green Tea and Lime Mousse* or the bed of moss used in the *Jelly of Quail* dish, or the ipod that helps intensify the *Sound of the Sea* (Blumenthal, 2008).

The Fat Duck had now a character which had been slowly developed throughout Heston's own experiences and contrasting of decisions, this is when we perceive each situation's own meaning better, when there is high contrast in them, the same happens with food, different textures or difference in temperatures such as hot and cold or an unexpected burst of flavour became a part of the restaurant's own identity and experience (Blumenthal, 2008).

Nostalgia by itself may not be the only key to trigger pleasure in the meal, one equally important criterion is the sense of reward whether we directly perceive it or not, it is there most of the times we take pleasure on eating. The sense of reward may come from several stimuli, work and get paid, win a competition and get the prize, lying on the bed after a hard day of work and so on – on eating reward comes the same way, probably the best cup of hot chocolate we had was on a winter cold day by a fire, the brand is not important but the sense of taking the best out of it. Reward is more into our lives than we know, the simple eating experience by its own when we are hungry for instance is highly pleasurable, that is why food tastes better when we are hungry, and when we are not, there is always room for dessert right? Desserts are known for being sweet and this comes from our tongue perceiving sugar in it, sugar are the most simple form of energy and we are naturally programmed to enjoy them, being a natural reward for our body (Blumenthal, 2008).

Thinking of joining nostalgia and reward together Heston could only think of a word to describe it "excitement" and that was the way he wanted costumers to feel when they came to eat at the restaurant, he kept saying whenever he felt excited about something "he was feeling like a kid in a Sweetshop" – it was the perfect metaphor (Blumenthal, 2008).

They thought of having a sort of guided presentation on the web site when people made the reservation and after reading it, costumer would receive at home a pack with a scent of citrus vanilla and caramel which would remind him of a sweetshop – when they arrived at the restaurant, the door would be perfumed with the same smell and this would trigger nostalgia unconsciously and put diner in the right track for the tasting menu full of surprises. By the end of the meal just as they were leaving they were given a sweetshop bag (with the pink and white strips) full of goodies such as the *Mandarin Aerated Chocolate*, *Apple Pie Caramel with Edible Wrapper*, *Coconut Baccy* among other things and, as they walked out, the fragrances of the sweetshop would be felt once again (Blumenthal, 2008).

2.5. On Job Training

Given the two sided objective of this paper, during the internship all the new information received and already consolidated during MICAS was used on job in order to understand how academic knowledge may be applied in the professional restaurant business and how it may have an impact on costumer overall experience.

Training took place at the Fat Duck Experimental Kitchen (FDEK), a specialized cooking laboratory that develops for the Fat Duck Group and which provided with all the methods, equipment and ingredients needed not only for a proper training but also for the sensory tasting which is analysed later in this paper work.

2.5.1. Working at the Fat Duck

"Enthusiasm is needed for a Demanding Job.

> The first criterion that we look for when we are recruiting for any position is the experience relevant to the job. Equally as important, is attitude and passion – and of course “personality”. That reassures us that you genuinely have passion and desire and that is what The Fat Duck feel is one of the most important ingredients when looking for someone to join us – Enthusiasm. It’s all about attitude and passion.
>
> Standards are exceptionally high and experience is essential, although full support will be given to you. Our commitment to training and personal development is paramount and we encourage and support promotional opportunities within this exciting organization.
>
> We have an exceptional reputation and an inspirational leader in Heston Blumenthal – our values come from the top we not only make sure that the dining experience is fun – this element resounds throughout the Company.” (Duck, Careers, 2014)

As said above in the Company values, the Fat Duck being well known abroad has its reputation for high working standards. High dedication is needed in order to keep up with the job, sometimes it is not easy – but then again it is one of the most celebrated restaurants in the whole world.

Currently the Fat Duck serves exclusively a fourteen course tasting menu (see Appendix 4), dining experience takes about four and half hours and is full of surprises, the front of house staff is extremely well trained as well as the kitchen staff. In order to serve the menu properly everything must be in the correct place and timing is crucial, nothing fails and there is no such thing as a mess in the kitchen. Everything is spot on and there is no room for error.

For the kitchen to work properly, organized *mise-en-place* is very important, some dishes in the menu take several days to complete so nowadays the Fat Duck is bigger and has more to it than the small kitchen when it first opened – in total there are around forty employees for forty-five costumer seats, almost 1-1 employee-costumer ratio. There are several areas or sections in which different tasks are done; there is the Preparation Kitchen, Preparation Pastry, Service Kitchen and two Laboratories.

As an intern we may apply for two different kinds of internship, kitchen stage or experimental kitchen stage. The main difference is the working area, one for production and the other for development, the commitment time is one month for the first and three month for development – as there are projects that take more than that to be accomplished.

The following will guide the reader though the procedures on each section in order to convey the complexity of the organization, which is required to provide the costumer the wonderful dining experience.

2.5.1.1. Preparation Kitchen

As the name implies, in the preparation kitchen is where most savoury food is prepared, this kitchen is located at the bottom floor of the Preparation House (see Appendix 9). There are no stoves in the Prep Kitchen, the job there consists of making the *mise-en-place* of a product until it reaches the stage of having to be cooked (in some cases they are completed because they do not need temperature to be finished) and then they are sent in appropriated boxes to the service kitchen across the road.

Chefs start at 7am and stay until they finish every task, usually it takes them until 8-10pm to completely finish. It is a demanding job and an important part of it is the intern who can do simpler but not less important tasks as picking the right leaves of parsley for the *Snail Porridge* or separating pink grapefruit segments for the P*oached Salmon* or even put the oak films in the boxes for the *Quail* dish.

Other tasks are performed by staff of the different sections such as cutting meat or filleting fish, or operating with expensive equipment such as the rocket evaporator (see Appendix 5) used to reduce several types of solutions.

A section which belongs to the preparation kitchen is the stock room, however it was placed in the Hinds Head kitchen, stocks are made and reduced there and the working time is from 5am until finish, usually around 4-6pm, in normal circumstances the regular intern only spends two days at the stock room.

2.5.1.2. Preparation Pastry

The preparation kitchen is on the top floor on the left in Prep House (see Appendix 9) and is divided into three distinct sections, white chocolate room, dark chocolate room and prep pastry, each section has a *chef de partie* who is responsible for his section (see Appendix 10) and usually has an intern helping, plus a *commis chef* helping all sections. They have the same exact labour schedule as the preparation kitchen.

In the white chocolate room the whisky gums are made as well as the chocolate cards, apple pie caramel with edible wrappers, all of them for the “Like a kid in a sweet shop” bag given to costumers at the end of the tasting menu. Other dessert dishes at the restaurant such as the peach gum for the *Botrytis Cinerea* dessert are made here as well. This room must be supplied with proper refrigeration as the white chocolate is very sensitive and the tempering process for the cards may fail (see Appendix 7).

The dark chocolate room is completely sealed in a corner because of the air gun work, which can easily cause dirt. Here there is only a *chef de partie* as the space is little and the type of work is very precise. We can see the vacuum oven (see Appendix 5) being used to aerate chocolate and several other dark chocolate works. Again the room is carefully maintained in order to make the tempering technique easier (see Appendix 7).

The third station consists in regular pastry, making sponge cake and biscuit among other things. A very particular and not easy task is done here which is making ice cream, the Fat Duck is well known for serving sweet and savoury ice creams in the menu, they are made in the edge of what ice cream science allows in order to achieve the best (see Appendix 7) they are all made here and to achieve the perfect texture and mouth-feel they are churned every day before lunch and dinner service.

2.5.1.3. Service Kitchen

In the service kitchen the job starts at 8am until dinner service is finished, around 12pm, it is the hardest section to do in the restaurant and the most demanding.

They receive *mise-en-place* from Prep House and have to do their own for many dishes, it is non-stop. During service everything is very well organized and there is no heat unlikely most traditional kitchens. Every chef in service knows his tasks really well and on top of that there are always two sous-chefs controlling dishes which come out to the dining room, from time to time head chef also shows and takes control over service.

It is important to say that there is no dish going to the dining room without being perfect, timing is crucial so everything is done with maximum attention.

2.5.2. Working at the Fat Duck Experimental Kitchen

The laboratory or experimental kitchen is where all the development for the entire Fat Duck group – except for Dinner by Heston Blumenthal – happens. There are two laboratories, the main one in the top floor on the right in Prep House and is mainly responsible for the savoury area, the second laboratory is in another House acquired by the restaurant where the offices and staff canteen are located, it develops everything which is sweet.

It is important to remind that the Fat Duck group, apart from Dinner is currently constituted by the Fat Duck restaurant. The Fat Duck group includes the Crown at Bray, the

Hinds Head, Heston Blumenthal equipment brand sponsored by Sage, Heston's food brand in Waitrose supermarkets and Cole's in Australia.

Development is different for each place whether it is for the Crown or the Hinds Head and it may be the starting of a new recipe or just the improvement of an old one, or even adjusting a recipe to make *mise-en-place* easier or for service to be better organized and faster. If the development is intended for the supermarkets brand the chef has to think of other kind of problems, such as shelf life of the product without compromising the flavour. When it is for the development of a recipe on a flyer for the costumer to do at home, the chef must be humble enough to simplify the recipe and use the most of Heston's brand products in it at the same time, the point is to sell the companies' products after all.

The fact is every case is unique and each chef works on his/her project individually, although full support is given by other development chefs and guidance by the head of development.

2.5.2.1. Routine

Working at the Fat Duck Experimental Kitchen (FDEK) is a lot different from being at the production area, development chefs work from Monday to Friday from 8am to 6pm, sometimes a little longer and other times less.

At 9am there is a daily meeting with the Fat Duck head chef where everyone explains what they expect to accomplish by the end of the day. This meeting lasts about twenty minutes, to give a simple example imagine there is a chef developing a pie dough and they want to add more fat to it, his/her objective is to find out how to add more fat to the dough without making it impossible to work with. Another example could be simply to study everything there is about a subject to trace a starting point (this is usual in new developments).

Each chef would then continue the day experimenting whatever needed to accomplish his/her objective for the day.

Every Thursday Heston would come to the main lab to discuss what has been made and he puts the projects on their right path, which is understandable as he is the owner and no one knows best what character the developing should have.

By Friday there would be an hour meeting at 5pm to discuss what each chef had accomplished in the last week and everyone would openly talk about the difficulties they had on achieving something or about a new thing they had discovered along the process, it was a time to discuss and brainstorm with others about what was done and what could be done better, exchange of ideas as simple as they can be, may trigger solutions for problems we could not solve by thinking for our own.

2.6. Experimental Assay – Sensory Tasting

The experimental assay consisted of a tasting and an inquiry both designed to demonstrate the question that lead to this dissertation: “does nostalgia triggered by sound affect the final taste perception of the *Sound of the Sea* dish?”

For this to be possible there were several meetings during the internship specifically concerning the study and a basic recipe of the *Sound of the Sea* dish was prepared.

2.6.1. Meetings

Three specific meetings for this dissertation were scheduled, first one on 19th February 2014 discussing the interest for both the student and the restaurant of having a study about multisensory perception: it was shared a common interest about the role of nostalgia in the perception of a dish and there was no doubt that the *Sound of the Sea* dish was the best recipe since it was developed in that concept and being an iconic dish. It was settled then the study would be about the Effect of nostalgia triggered by sound from the *Sound of the Sea* dish, in the final perception of taste.

The second meeting was on 12th of March 2014 it was settled that a simpler version of the Sound of the Sea for the fact it was highly complex to make (see Appendix 8), after some discussion the main components that make the dish were chosen a basic recipe remade (see Appendix 11), It was also asked by head chef in this meeting for a document which would explain what the study was about and the equipment needed, for that the it was used as a base, the study proposal submitted to the University before the internship to keep the same methodology (see Appendix 12).

The last meeting was on 31st of March 2014 to figure out if the check list for the equipment and material needed for the sensory tasting was complete.

2.6.2. Inquiry

The inquiry for the tasting (see Appendix 13) had six question with only multiple choice answers, four of them regarding the dish and its saltiness, freshness and overall enjoyment, these had numerical variants from 1 to 5 scale, being 1 the lowest grade and 5 the highest. The other two questions were about the nostalgic part of the study and had only two variants.

2.6.3. Recipe Formulation – *Sound of the Sea* Simple Version

The *Sound of the Sea* dish (see Appendix 8) has over eighty different ingredients and that would make the tasting very difficult, after some discussion about which ingredients truly make *Sound of the Sea*, a basic recipe was remade containing: the sand, foam (sea), four seaweeds (ice lettuce, sapphire, tosaka and codium), ponzu sauce and one fish (yellow tail). For detailed information see Appendix 11.

2.6.4. Sensory Tasting and Sample

On the 1st of April sensory tasting took place at the Fat Duck facilities (canteen) with nine people who lived or took frequent vacation by the sea side from outside the company and who did not have any knowledge of the *Sound of the Sea* dish concept took the test. The selection was made by inviting individuals from the area via email, people were asked about their knowledge about the fat duck and its iconic dishes before being accepted and only the ones who did not mention the Sound of the Sea and had frequent vacations on the sea side participated in the sensory tasting.

Tasting took place at 14.00h, the average person has lunch between 12.30h and 13.00h. This was thought to avoid hunger nor satiety; 1h 30m is enough not to feel full after lunch and not enough to be hungry.

There were two phases, one of them with nostalgia factor and another without it, this was controlled by adding sound of sea side while tasting was occurring.

There was a time limit of five minutes for each phase, except on the one with sound which had one extra minute hearing it before tasting, to get involved with the environment. The gap between each tasting was five minutes.

There were on the tasting table, printed inquiries, pens and glasses filled with water to clean the palate.

To avoid subjective results, out of nine tasters four started tasting without the influence of sound and the other five on reversed. The sound was played from loud speakers.

Every person that was part of the tasting had the exact same influences as the others, no more than the *Sound of the Sea* dish and the sound, the sittings were individual and the room was empty.

2.6.4.1. Equipment

In order to properly do the sensory tasting there were several materials and equipment used:

- 9x individuals sits, without any interference (other people around, background noises, bright colours, paintings, etc)
- 18x glass filled with water
- 18x printed inquiry
- 9x pens
- 18x *Sound of the Sea* dish (simplified version)
- 1x player for the sound with loud speakers
- 18x fork and knife silverware
- 18x napkins

2.6.4.2. Data Recording

Inquiry data were coded into an Excel sheet to later be worked in the statistics computer software designated by R, version 3.0.2 for windows. Given the fact most variables are of qualitative nature, descriptive statistics analysis was used.

Chapter III – Results and Discussion

3.1. Internship Experience

Working at the laboratory as I found out not long after I started is not always easy. I had met some of the Fat Duck staff before my internship and most of them said development was the easiest job in the company, because development chefs worked less hours overall, however development turned out not easy at all.

Before I started my Master's degree I had already read the Fat Duck Cookbook, Heston's story and approach on cooking, it was that book which made me want more for my career as a chef, I've always been very curious about how things work and eventually ended up searching for a plausible explanation. As it is referred in chapter II, the scientific knowledge on cooking is deep at the Fat Duck and that made me wonder if I would really be able to contribute with something for the company at my internship.

There were many lessons I have learned while at the Fat Duck, but not the type I was expecting. The following discusses my internship from a personal point of view, for detailed information please see Appendix 14 – Internship Journal.

3.1.1. Summary

I started on the 8th of January at the pastry development kitchen and there was a lot going on at the moment the team barely had the time to introduce me to the working methods. Learning on the job is always good and I had some pastry background so everything went just fine. We spent the first week almost only making *mise-en-place* for the upcoming television show Heston's Great British Food and we were working on chocolate for that specific broadcast. I was able to prove myself useful for the team and they started trusting me some projects on my own later on.

Indeed development seemed easy when I only had to follow head chef's commands but it all changed when I was given a project and had to take initiative to get results.

The first development project I can really call my own was for the Crown at Bray, the team wanted to make a citrus pie, something very acidic with some bitterness and with the right amount of salt to boost everything. I started gathering recipes that I had enjoyed in the past and chose one of them, from there I made a sample and had head pastry development chef to try it, she enjoyed it, told me it was a good base to work on. After that she explained me some criteria I needed for developing the recipe in the right path. First, because it is a pub we must keep it very simple to make and easy to plate, they do not have highly qualified staff and one day they make the recipe very well but not always, second the food cost must remain low as it will have the price of average pubs, third it has to have a long shelf life after being made so it does not have to be constantly remade, even the meringue had to hold for at least the whole service without having to be whipped again and again during service.

The recipe to start working with was a salty short-bread for the base, a bitter preserve made with the peel of lemons, *yuzu* (Japanese citrus) curd and a citric Italian meringue. Short bread and the preserve were both very good they were simple and easy to make so I started working on the curd. A traditional curd is made on the stove, stirring until it reaches the right consistence, with care not to cook the eggs, so I thought of a way to make it impossible to ruin, as it usually happens if you forget it by the stove or let the right texture pass, so I decided to run a trial cooking sous-vide. I knew lecithin in egg yolk starts to coagulate at 60 degrees and at 64 (see Appendix 6) has a well dense consistency and that usually happens when the eggs are mixed with liquids such as the *yuzu* juice and the milk I had in the recipe, we bring the mixture to 80 degrees to fully pasteurize and properly coagulate the lecithin, so I tried with 80 degrees until reaching core temperature, strain it cool it down to 40ºC and then add the butter and mix everything. The result was good but not fully satisfying, the texture was not right, but the head chef enjoyed the cooking method and if I could make it like that the Crown staff´s life would be a lot easier. I eventually found out that emulsifying the butter with a hand blender made a tremendous difference on texture. Another problem was the very expensive *yuzu*, so I ran several trials with different % of lemon, lime and pink grapefruit juices (main flavours in *yuzu* – which I found out using a database with all kinds of ingredients and their main flavour molecules, see Appendix 5) over and over again, I had a control curd made with only *yuzu* to compare, I might have done approximately twenty different curds and none of them tasted as good and on top of that it seemed the less *yuzu* juice I put the less creamy the curd was. It was getting repetitive and I could feel some frustration, after some days making curds the head chef of the Fat Duck decided which one to use.

I had the curd and moved to the meringue, Italian meringue was the one which lasted longer after whipped but it got lumpy after a while and it was not easy to make, it required attention. So I went studying the science behind foams and found some information that led me to my next trials – I had to consider factors as temperature, starch, sugar and pH. Temperature denatures albumin irreversibly (stabilizing the foam), starch absorbs any humidity in case some of the whipped denatured protein reverts to liquid, sugar and acid help create a better and more stable network between proteins.

I ended up making it sous-vide the same way as the curd, mixing in the bag withes, sugar and citric acid, cooking it until pasteurized and then whipping it in the machine with confectioners icing sugar (which has 1% of starch to avoid lumping) until cooling to room temperature.

The project eventually got accepted and it was time to implement it at the Crown, unfortunately I did not have the opportunity to participate in it.

Later I was trusted with a development for the Fat Duck, the team wanted something green in the rhubarb dish that was going to enter the menu for the season. We started running trials with lemon balm (flavour chosen by head chef) on fluid gel, it came out harder than we expected, it was just too hard mainly because of the colour and after a few days trying we decided to go for an oil, so we made a lemon balm oil, it consisted of picking the leaves (the stalks diminish the colour because they have less concentration of chlorophyll), add to grape seed oil and freeze, emulsify in the Paco-Jet (very powerful blender, see Appendix 5) and let strain overnight hung in muslin cloth – the result was a lemon bam clear and green oil. This time they sent me to preparation pastry to explain the sous-chef there how it was made so they could start looking for the best way to produce it since it took two days to make.

By the end of the second month I met with the Fat Duck head chef to discuss my dissertation subject I had in mind, inspired by the Fat Duck quest into multisensory perception. He was very interested and suggested to investigate the role of nostalgia, triggered by sound from the *Sound of the Sea* dish.

I switched to the experimental kitchen and started all over, new faces, new places for equipment and more important, new working methods. I felt they had a lot more knowledge in this laboratory, at least when I arrived they were speaking about the effects of acids on the texture of meats among other things. The head development here trusted us a lot more and gave a much more freedom to try out new ideas.

I was given a really hard project which consisted on making jelly beans to enter the sweet shop bag (which is, in a way, the representation of Heston's childhood, which makes expectation very high). I started, again with a base recipe they had already tried and started mastering the technique of making them. I found out the perfect texture they were looking for it was at 61 brix (% of sugar content in the solution, see Appendix 5) and went from then on, letting them dehydrate more, or less time and at different temperatures and relative humidity also changed texture.

When I achieved a good texture, the panning process started, I started by studying everything related to soft panning and ran trials every day I could, this went on until the end of my internship one and half months later. The problems with panning were getting more and more complicated to solve, the temperature of the room was one of the most complicated ones – I found myself making an ice bath beneath the panning machine in a way that the bottom of the bowl would touch the iced water in order to get the temperature inside down, but it was not enough so I started using a nitrogen gun and started pumping the cold steam inside the bowl, all to end in failure. At the end of my stage I ended up with a sample that was far from perfect but the improvement was noticeable – so I passed all the knowledge I had about it to the new intern.

At the same time I was making the jelly beans, several other projects had to be done, simpler ones for the Waitrose supermarkets such as recipes to show in flyers meant for people to grab while shopping and try to cook at home. These would be projects for 2 day maximum, the problem is there were only two people who could approve them – the Fat Duck head chef and Heston´s brand developer – and they would not often be pleased and I had to do, for instance a simple chicken sandwich over and over again. I found it to be very frustrating, I thought if I really was worth nothing if I could not even make a sandwich work. I figured out, by the end of the internship, that frustration is development's daily basis and the most difficult part to overcome. As a chef we are taught to follow our head chef's orders, and after a couple of tries we eventually do it right, which is the opposite case of development. As for the chicken sandwich it did not mean it was not good but it just was not what the team was looking for.

Failure became part of my daily routine, and the simpler the projects were the worse but I kept my working methods that I had from the beginning, writing everything down, having a control to compare and go from there, using all the valuable criticism to my advantage, trying to keep up with the high standards of the Fat Duck's name.

The last day I spent at the Fat Duck I had my observation day which is a way for the restaurant to show the concepts behind its dishes and thank its intern's commitment, and it consisted on watching the service kitchen working and trying every dish on the menu.

Due to the Fat Duck's private policy, photographs could not be taken nor can any formula, recipe or information belonging to the Company be mentioned or published to the general public.

3.1.2. Overview

As referred before, this dissertation had two main objectives and one of them was to learn on job how scientific knowledge gathered during graduation and the Innovation in Culinary Arts and Sciences master's degree may be applied in the professional business.

The internship at the Fat Duck was not chosen by chance. As it is explained in Chapter II the restaurant is known for its scientific approach to cooking and multisensory experience to costumers. There could not have been a better opportunity than not only to observe the procedures at the restaurant, but also to actually be part of the Fat Duck's team.

To be a professional chef meant for me, at least before my internship at the FDEK, o follow my leader's instructions, try them repeatedly and eventually master them. A particular task in the kitchen was made that way because that was the way it was supposed to be. My head chef was taught by his head chef that way and the secrets are passed down in the hierarchy as some sort of family heritance.

Reproducing classical methods science in the kitchen was not even considered before, however this was not the reality I encountered at the Fat Duck Experimental Kitchen which started following the path of science applied to cooking years ago.

As soon as I started at the FDEK I was expected to already have a good background in the development area (including scientific knowledge), which I believe I had, not only had I studied the Fat Duck Cookbook but also attended specific classes during MICAS such as Advanced Culinary Techniques (ACT), Food Products – Uses and Culinary Applications (FPUCA) and Research and Development of Menus and wine list (RDM) which provided the know-how and methodical approach needed for development at the Fat Duck.

During the four months I worked at the FEDK there were many challenges which were summarized before in this paper, however there were other types of working methods (not necessarily mine) which I was able to execute or observe and that helped me understand how to use knowledge as a tool, just as important as a chef's knife.

Throughout MICAS there were several professional chefs who went to EHITHS to give lectures about specific subjects, one of them was responsible to introduce the new machinery used in modernist restaurant. Among them were the rotary evaporator, dehydrators, high power blenders, vacuum filtration machines. Although the class was very interesting and enlightening, the students did not have the chance to use the machinery freely as they are very expensive. At the FDEK all of these machines and more complex ones such as the rocket evaporator, centrifuge, vacuum ovens, freeze dryers, deep freezers, etc., were available to use for development chefs (including interns – although with supervision) to try their ideas.

Not only did the Fat duck provide materials but also ingredients to experiment, no matter what it was that the development chef needed, it was not hard to get it. I understood that when a company has such prestige as the Fat Duck, providers want to show their products and arrange meetings with (in this case) the Fat Duck's development chefs. For the Academia, such as EHITHS, getting too specific ingredients may not be easy sometimes for many reasons – being an Academic Public Institution, and not an enterprise for commercial purposes and the fact that the world of gastronomy being now starting to be explored in Portugal are among them.

During the master's degree there were other lectures with experts from different areas and chefs who would present us new cooking techniques. The experts who lectured were very good, however some of them did not belong to the cuisine area (because it is just starting to be explored in Portugal) therefore it was hard for the students to make the connection from theory to practice. The ones that were professional chefs had the characteristic, brilliant at cooking however some of them (not all) lacked deep theoretical knowledge needed to explain why it was done that way – because in cuisine in Portugal is still very attached to the classic techniques.

At the FDEK I had the opportunity to meet both brilliant chefs and scientific minds, and one lesson I had the opportunity to witness was that the difference between the two – a professional chef and one who is also brilliant but is comfortable with science in the kitchen – is that while the first one may need one hundred trials to develop an idea, the second one may sometimes reduce the number of trials by sixty, saving both time and money.

However being at the FDEK was very overwhelming at first, with time I started feeling more confident and was able to apply a lot of valuable knowledge that I had gathered during MICAS, also the academic way of working gave me the background needed for an experimental approach to cooking. I was able to, unconsciously, build a methodical way of working – however, very practical at the same time due to my experience as a professional chef. In the end I believe it was what the Company was looking for and I feel I proved myself useful as it is suggested in my internship evaluation by Head Chef, and Co-advisor of this dissertation, Jonny Lake (see Appendix 15).

In summary, to be a good professional chef is important, however if one masters the science of cooking the better professional he will be. It is also very important both to have good academic background and proper on the job training experience – as suggested by Wood (2004) – in order to understand how the two have such a symbiotic relation.

3.2. Experimental Study

The following is the presentation of the results obtained from the experimental study conducted at the Fat Duck facilities and their correspondent discussion.

3.2.1. Sound of the Sea

The *Sound of the Sea* dish was first registered in 2007 (see Appendix 8), it is a very complex combination of sea ingredients with Asian nuances; the core components of the dish are: the Sand, made of cod liver oil, panko miso, and maltodextrin; the Sea, a seaweed broth and lecithin (later aerated with a hand blender); Seaweed plants; *Ponzu*, classic Japanese sauce very rich in umami, made with sake, fresh *yuzu* juice, *katso bushi* and *kombu*; the Fishes, currently three types of cured fish.

The dish is served on bespoke plate made from walnut wood and with a conch with a music player inside (containing sounds of the seashore). The conch is placed at the table and before the dish to give time for the costumer to get in place and create context.

The *Sound of the Sea* started to be developed because of Heston Blumenthal's interest in multisensory perception and the effect of sound, context and nostalgia in flavour perception (Blumenthal, 2008).

In an early stage the Fat Duck team, started experimenting with oysters with the help of Dr. Charles Spence, who has a close working relation with the restaurant, is an expert in the field of multisensory perception and specialized in the influence of sound on flavour perception. The experiment studied the perception people had on eating oysters depending on the sound they were listening to. It showed that listening to the sound of the sea made participants feel the oyster tasted better, saltier and fresher than when listening to barnyard noises (Spence, 2008).

Research of other authors suggest a single and specific memory that is contextually the same for everyone allows each individual to perceive his own interpretation of the memory triggered (Verhagen & Engelen, 2006).

Regarding the *Sound of the Sea* if one was to show a picture of the sea side to the costumer it would be too specific, preventing diners from mapping their own sensory image in the orbitofrontal cortex (Shepherd, 2013).

Theoretically this allows the experience to be cross cultural and not to be affected by language. Although it permits reaching a wider number of people, this may be limiting because each individual have his own seaside memories already mapped in his brain (Prescott, 2008).

3.2.2. Sample

Tasters sample was of nine people who lived or took frequent vacation by the sea side – initially to be thirty for obtaining significant results. The number of tasters was reduced because of the company policy not allowing every person from outside to be introduced to their work and employees could not participate either because they already know the concept behind the dish, having high expectations that could affect the results.

An agreement was settled of inviting only twenty random people who would be adequate for the tasting, who did not know the dish and lived or went frequently on vacation to sea side places, out of these twenty only nine made to the tasting. For the reasons explained the sample was shortened and on account of that the study that was undertaken intends to be a preliminary approach which can be used in the future for further experimentation and understanding.

Although the tasting was thought for 14.00h to prevent people from being either hungry or full from lunch (which on average people in the UK have around 12.30h), there was not a way to control this factor as participants were not asked what time they had their last meal. This may have influence on the results, some authors show that one of the natural factors which influences food appreciation is hunger and satiety – the meal is felt, meal more delicious if taken hungry and less delicious when full (Yarmlinsky, et al., 2009).

The participants may have had some expectation of what they were about to eat, although subjects were not familiar with the *Sound of the Sea*, they most likely knew about the Fat Duck concept. Some authors defend that expectation influences one's perception of food, while one is eating, subconsciously there is part of the eating experience that was previously mapped, either because it had been eaten already or even for the fact of the Fat Duck name (fine dining experience) which triggers different expectation from a regular restaurant, these facts alter the multisensory experience congruency and may result in a different perception of flavour (Yeomans & Chambers, 2008).

Regarding the experiment it was not possible to find a proper room for the tasting, participants sat down at long tables at the Fat Duck staff canteen apart from each other, there was no barrier between them, hence visual contact was possible during the tasting - although answers were not possible to copy because they had plenty of empty space from one another.

Apart from these experimental deviations, every other requisite was accomplished accordingly.

3.2.3. Tasting Assay

For data to be recorded, the sensory tasting had an inquiry (see Appendix 13): the Likert scale was chosen for the fact it allows precise evaluation for the type of data representation further discussed. It also is considered ideal for hedonic tasting evaluation (Santos, Ozeki, Oliveira, & Kimura, 2009).

The first question was intended to evaluate how sound or the absence of it influences saltiness perception of a dish, which supposedly should as a previous experiment demonstrates: participants tasting the same oysters felt they were saltier when hearing sound of the seaside (Spence, 2008).

Question 2 was thought to prove how sound of seaside influences freshness perception of a dish. Similar experiment suggested it has significant influence (Auvray & Spence, 2008) and also that it promotes context for the dish (Mesz, et al., 2012).

In order to understand how sound affects in the tastiness perception of a dish (mouthfeel, and overall taste) question 3 was in the inquiry. Several studies suggest sound plays a role in the appreciation of food (Spence, 2012), as well as multisensory perception of flavour significantly affects how tasty a dish may feel (Verhagen & Engelen, 2006).

Question 4, as well as question 4.1 were not made in a Likert scale but with dichotomy answers because they were meant to show yes or no answers. Question 4was meant to understand if nostalgia was triggered or not (with and without sound), and 4.1 to know if the memory (nostalgia) triggered was a good or bad feeling. This is important because it is suggested that nostalgia plays an important role in the appreciation of food (Li, et al., 2010) and it will depend on a previous experience that a particular memory triggers (Gottfried, et al., 2004).

Question 5 was meant to understand how the overall experience differs when there are more sensory systems integrating the multisensory experience and how they influence the overall enjoyment of a dish. This fact is proved to be true, the more systems activated in our brain flavour system the richer the experience will be, either for better or worst depending on the images associated in the brain (Shepherd, 2013).

The following are the results of the experiment (see Appendix 16), which were analysed later (Table 2), in descriptive statistics using tables and box-plot representation.

Individual	Sound	Q1	Q2	Q3	Q4	Q4.1	Q5
1	1	3	5	4	1	1	4

2	1	3	4	4	1	1	4
3	1	3	4	5	1	1	5
4	1	2	3	4	1	1	4
5	1	4	5	5	1	1	4
6	1	3	3	4	1	1	4
7	1	3	4	4	1	1	4
8	1	4	5	5	1	1	4
9	1	3	3	4	1	1	4
10	0	4	3	3	1	1	3
11	0	1	3	3	0	n/a	3
12	0	4	4	4	0	n/a	3
13	0	4	3	5	1	1	4
14	0	3	4	5	1	0	4
15	0	2	3	4	1	1	4
16	0	2	3	3	1	1	4
17	0	4	5	4	1	1	3
18	0	3	4	4	1	1	4

Table 2 – Raw data gathered from sensory tasting. There were 9 participants, however 18 individual results – the tasting had two phases (phase 1: individual 1-9; phase 2: individual 10-18), one with sound influence (Sound – 1) and another without sound influence (Sound – 0). Q1: Question 1, Q2: Question 2, Q3: Question 3, Q4: Question 4, (Reminds – 1; Does Not Remind – 0): Question 4.1 (Good Times – 1; Not Good Times – 0), Q5: Question 5.

Results were divided into two parts (both showing direct difference between sound influences): the first gathers all dichotomy data and the second with descriptive data representing quartile distribution with boxplot graphics.

Variable Sound has two possible realities, corresponding to the two stages of the inquiry (Table 2) – first with sound influence (1) and second without sound influence (0) they were changed to Sound and No Sound accordingly.

Variable Q4 corresponding to the question: Does the dish remind you of something familiar? (if you answer Does not remind me, move forward to question 5) had a positive answer “Reminds” (1) and negative one “Does not Remind” (0).

The final dichotomy variable was Q4.1: What was it that felt familiar? The answer (1) corresponds to “Good times spent on the sea side” and (0) to “Not so good times spent on the sea side”. The results are represented in the following Table 3 for easier discussion:

Individual	Sound	Q4	Q4.1
1	Sound	Reminds	Good
2	Sound	Reminds	Good
3	Sound	Reminds	Good
4	Sound	Reminds	Good
5	Sound	Reminds	Good

6	Sound	Reminds	Good
7	Sound	Reminds	Good
8	Sound	Reminds	Good
9	Sound	Reminds	Good
10	No Sound	Reminds	Good
11	No Sound	Does not Remind	n/a
12	No Sound	Does not Remind	n/a
13	No Sound	Reminds	Good
14	No Sound	Reminds	Not Good
15	No Sound	Reminds	Good
16	No Sound	Reminds	Good
17	No Sound	Reminds	Good
18	No Sound	Reminds	Good

Table 3 – There were 9 participants, however 18 individual results – the tasting had two phases (phase 1: individual 1-9; phase 2: individual 10-18), one with sound influence (Sound – 1) and another without sound influence (Sound – 0). Dichotomy variables converted into text. Sound (Sound -1, No Sound – 0); Q4 (Reminds – 1, Does Not Remind – 0); Q4.1 (Good – 1, Not Good – 0)

One can observe sound influence subjects 1-9 reminded participants of something familiar, i.e., sound evoked a memory (Table 3), this suggests the requisite nostalgia was triggered by sound. Some studies refer this phenomena is possible and likely to happen since our hearing system is part of the integration of multisensory perception (Auvray & Spence, 2008), therefore connected to our Orbitofrontal cortex (OFC) and memory accessible data (Li, et al., 2010) .

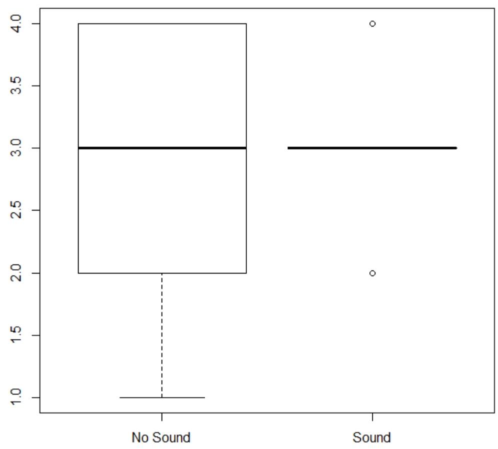
Also all Q4.1 were answered with “Good times by the seaside” meaning the triggered nostalgia corresponded to a pleasant memory. According to some authors, nostalgic pleasant memories are more likely to promote a better overall eating experience (Yeshurun & Sobel, 2010).

However, without the influence of sound, the dish did not evoke any memory for two participants suggesting the dish alone (taste, texture and aroma) is not enough for the multisensory experience in this case, i.e., for the activation of memory followed by nostalgia and rich flavour image represented in the OFC with the pretended context of the *Sound of the Sea* dish. These individuals, as showed in Table 2, answered Q5 with the lowest values, suggesting – as defended by some authors – nostalgia triggered by sound affects the overall multisensory experience (Verhagen & Engelen, 2006)

The remaining participants who did not have the influence of sound and evoked memories, all were pleasant ones with the exception of one.

This exception might be explained by the dish itself reminding (since this person answered Remind in Q4) of something unpleasant due to its flavour profile, which is very rich in umami, and citrus aroma (not acidic in the mouth) probably similar to some rich seafood which he/she might not have enjoyed. By itself, taste of the dish evoked an unpleasant image.

However when analysing further Table 3 one can observe that the same person had to answer Q4.1 with "Good times by the seaside" when sound was being played. This can be, as other authors suggest, for the fact of introducing another sense in the multisensory experience. It might dramatically change flavour profile of the dish, therefore representing a different image in the brain and setting different context – evoking distinct nostalgic feelings affecting pleasantness (Shepherd, et al., 2007).

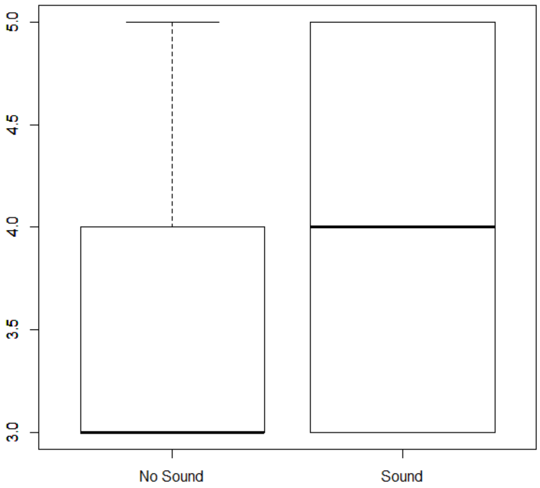


Graphic 1 – Box-plot Q1 (Question 1).

Relatively to Question 1: How salty is the dish? (1-not salty at all; 5-very salty), data distribution is shown in Graphic 1. It is possible to observe that with sound influence the perception of saltiness of the dish tends to stabilized as the 1st and 3rd quartile are of (3), same value as median and two outliers were found with values of (4) and (2). On the other hand, saltiness perception without sound influence had wider amplitude between quartile, with values of (2) for 1st and (4) for 3rd, minimum value given was of (1). Although distribution without sound influence is wider, it had inferior mean (3), being (3.11) with sound. It also shows that 50% of participants that had sound influence answered (3) for saltiness intensity and without sound 50% answered between (2) and (4). These findings might suggest sound and context triggered with nostalgia affects our saltiness perception of a dish turning it saltier. Similar results were obtained in an experiment carried out by Dr. Charles Spence and Chef Heston Blumenthal with oysters (Spence, 2008). Other studies suggesting sound influence on flavour perception showed it can enhance particular flavours such as bacon, when hearing sizzling sounds (Spence, 2009).

Question 2 was in the inquiry to understand how perceived freshness of the *Sound of the Sea* dish differs when there is the influence of sound, the data results are represented in Graphic 2.

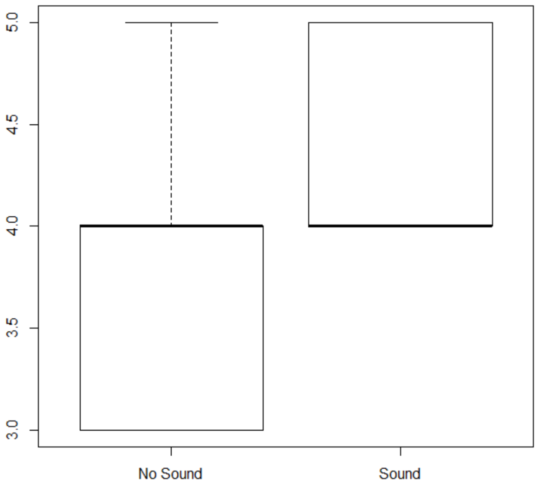
Without sound influence 1st quartile had the same value of median (3), 3rd quartile was (4) meaning 25% of subjects answered between (3) and (4), box-plot maximum was of (5) and minimum of (3). On the other hand, with sound the median was (4), 1st and 3rd of (3) and (5) accordingly, being the minimum and maximum values as well which translates in 50% of answers between (4) and (5). It can be assumed context and nostalgia triggered by sound have high influence on making a dish seem fresher, median is superior (4) and more of the data is wider distributed in the 3rd quartile. Mean values are of (4) with sound and (3.56) without it, which enhances freshness perception of the dish (similar to the freshness of the sea) when sound of the sea side is played. Different studies suggest the same, sound is crucial to create context and enhance eating experience, for instance when eating crisps, the sound produced from opening the packs helps to create that context and make them feel crispier (Knoferle & Spence, 2012).



Graphic 2 – Box-plot Q2 (Question 2).

Other authors also defend that nostalgia is very important creating context and enhancing the experience after (Yeomans & Chambers, 2008), in the case of Question 2, data suggest the triggered memory of the seaside creates context and makes the participant feel the dish fresher, mirroring the freshness of the seaside while on vacation.

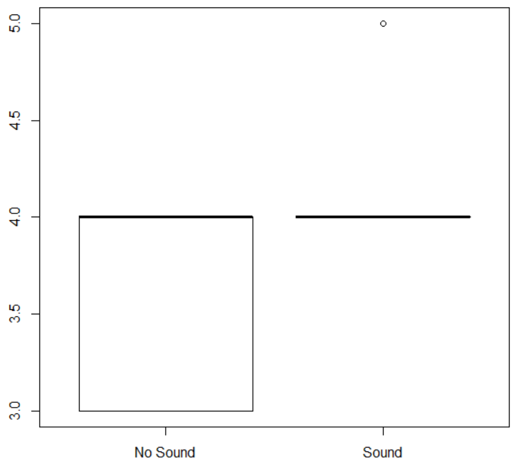
Graphic 3 represents data distribution of question 3: How tasty is the dish? (1-not tasty at all; 5-very tasty). However both have the same value for median of (4), clearly data distribution with sound influence is wider on 3rd quartile and without sound on 1st quartile, it means there were more participants answering between those values – sound above (4) and without it under (4).



Graphic 3 – Box-plot Q3 (Question 3).

Maximum with sound influence is of (5) and minimum of (4) meaning 100% of participants answered between (4) and (5). Nevertheless 50% answered between (3) and (4) without sound influence. These are distinct values which suggest that with more complex multisensory perception tastiness of a dish is significantly improved. To enhance this possibility, with sound influence the average was of (4.33) and without it was (3.89), showing higher evaluation of tastiness when sound triggers nostalgia. Similar findings are suggested by some experts in the field: it is more likely to enjoy a meal when several senses are activated, the more activation in our flavour system in the brain the tastiest a dish should feel (Prescott, 2008). Others also show sound is very important in food appreciation, making it much more enjoyable (Auvray & Spence, 2008).

Regarding Question 5: How much did you enjoy the dish? (1-did not enjoyed at all; 5-enjoyed very much) although both have the same median (4), different data distribution may be observed (Graphic 4), with sound influence 1st and 3rd quartile are of (4) meaning 75% of participants evaluated the overall experience as (4), an outlier exists who answered (5). Distribution of data without sound influence is mainly below median value, with a minimum of (3) corresponding to the 1st quartile, this means 25% of participants had an overall experience of (3) and 50% of participants answered between (3) and (4) this last one being the maximum value. Average values are of (4.11) and (3.56) with and without sound, accordingly. This translates in a higher overall experience, therefore suggesting nostalgia triggered by sound – which puts participants in context with the seaside landscape – affects the final perception of taste, resulting in better overall enjoyment of the *Sound of the Sea* dish.



Graphic 4 – Box-plot Q5 (Question 5).

These results also suggest that one has an aptitude to relate several senses, and to understand one of them as the result of the other, i.e., in this case taste is highly influenced by sound. Similar findings showed that everyone has this ability – called synaesthesia – considered a disease for a long time but understood as key factor to one's own sensory interpretation of the world nowadays (Barnett, 2011).

However this study does not explore an extreme case of synaesthesia as shown by others that a person is able to taste creamy flavour when hearing the word “quick” (Ward, 2008), it highly suggests there is a synesthetic condition, thus putting forward the hypothesis of one’s living in his own multisensory perception world (Spence, 2008).

Having that, one can assume eating is a multisensory experience. Nevertheless, the experiment also suggests it is unique for each individual, as the results vary from each participant. This might be explained for the fact that the multisensory experience from the *Sound of the Sea* dish triggers (according to the sample studied) a strong sense of nostalgia and emotion. While eating, the amygdala processes emotion related to the memory triggered and the overall enjoyment of the dish depends on the memory triggered as suggested before (Shepherd, 2013).

Prescott (2008) defends that this type of phenomenon happens due to our natural ability for associative learning of food. Each individual is able to evoke emotional memories by an eating experience.

The tasting assay results propose that nostalgia was triggered from sound influence, and this helped creating context for the dish and the fact that most participants found the dish fresher and saltier is proof enough that it evoked seaside memories and taste related to it (Spence, 2009). It can also be explained by the fact that the orbitofrontal cortex is closely related to memory and emotion and the eating experience depends on the mapping of the flavour molecules together with the inputs from other senses (Shepherd, et al., 2007).

The results of this study, which is a preliminary approach, highly suggest that multisensory experience is crucial for the enjoyment of food, not only sound helps creating context but also helps enhancing saltiness. It also suggests, nostalgia can be triggered by hearing sound and when feeling it, participants showed more intense experience, as defended in other studies (Verhagen & Engelen, 2006). Not only that but when nostalgia was from a pleasant memory, it suggests the overall experience was better evaluated, when a pleasant memory is triggered, our reward mechanism starts and the experience from then on is highly improved. Apart from this, results also evidence flavour perception is unique to each individual, i.e., each person has their own perception of the eating experience.

Conclusion

Science in the kitchen is used nowadays as a tool to control the results on creation of new dishes by the professional chefs, however not only the fields of gastronomy, physics and chemistry are being studied, subjects such as biochemistry, physiology and neuroscience are of extreme importance to understand and enhance the experience of eating.

This is valuable to chefs, its understanding allows better results and more complex creations. Regarding the eating experience, there are several senses and sensations affecting flavour perception – which is, in the end, the multisensory perception of eating. Senses such as touch, sight, sound, smell and taste, and sensations such as emotion, nostalgia, context and expectation affect flavour perception.

The internship was a very important part of the dissertation, as a professional in the area of hospitality and restaurant. By analysing the time one had at the FDEK it was possible to observe that:

- A chef with scientific knowledge will create his own dishes more easily;
- Laboratory equipment may be brought to the kitchen for the chef's advantage;
- Cooking is no longer strictly attached to classic techniques;
- Academic knowledge and methodology are important for development;

The study was a preliminary approach, to the effect of nostalgia triggered by sound on flavour perception; it had nine participants, who tasted the *Sound of the Sea* dish two times, one with the sound of the seaside influence and the other without it. The results of the assay indicated that:

- Nostalgia triggered by sound made the *Sound of the Sea* affect flavour perception, it seemed more delicious;
- Sound of the seaside made the dish seem saltier;
- The same influence made the dish seem fresher;
- It made participants evaluate higher the overall deliciousness of the dish;
- Sound may create context and affects enjoyment of the dish;
- When nostalgia is from a pleasant memory the dish is better evaluated overall;
- Participants all had a different experience, therefore everyone lives in different realities of the eating experience.

Both the experimental assay and the internship at the Fat Duck Experimental Kitchen provided a better understanding of how complex modernist restaurants and the multisensory experience of eating are.

As said before, the study was a preliminary approach due to the sample constrains. This study would continue the search for deeper understanding effect of several senses and emotions can have on flavour perception in order to give the modernist chef the tools to better control his creations and to provide clients with memorable multisensory experiences.

The intended bilateral subject of this dissertation was achieved. On one hand knowledge gathered during Master in Innovation on Culinary Arts and Sciences was consolidated by taking an internship, learning on the job at one of the most iconic restaurants of all times, the Fat Duck – which is known for its multisensory eating experiences and for bringing science into the modern model of professional kitchen we see today. On the other hand an experiment was conducted, which made possible to discuss the effect of nostalgia triggered by sound – from the *Sound of the Sea* dish – on flavour perception. It contributes to the multisensory experience of eating triggering feelings, which affects our perception of food in more than one way.

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Appendixes

Appendix 1 – Internship Agreement

eshte

Company contact	
Name	SARAH SOBO
Position	PA to Head Chef
E-mail	sarah@thefatduck.co.uk
Phone	+44 1628 763321
Fax	+44 1628 763322

Additional Conditions

Salary	Meals		Transportation		Accommodation	
None (unpaid)	Meal Allowance	Provided by the Company	Transport Allowance	Company Transport	Accom. Allowance	Provided by the Company
	No	Yes	No	No	No	No

Remarks

Sarah Sobo, PA to Head Chef

Job Title - Signature

eshte

ESTORIL HIGHER INSTITUTE FOR HOTEL AND TOURISM STUDIES

Training Confirmation Form

General Information

Company Name	SARAH SOBO
Company Manager	Heston Blumenthal
Address	THE FAT DUCK ,HIGH STREET, BRAY
Post Code	SL6 2AQ
Telephone	+44 1628 763321
Fax	+44 1628 763322
Website	Thefatduck.co.uk

Additional Information

	Trainee's Name	Application Areas	Work Placement Period	
			Start	End
1	Filipe Leonor	Experimental Kitchen	08/01/14	04/04/14/
2				
3				
4				

	Trainer	Trainer's Position
1	JONATHAN LAKE	HEAD CHEF
2		
3		
4		

eshte

TRAINING EXPERIENCE AGREEMENT

This agreement shall be signed by:

a) University

ESTORIL HIGHER INSTITUTE FOR HOTEL AND TOURISM STUDIES
Av. Condes de Barcelona, 2769-510 Estoril
PORTUGAL

b) Institution/ Hotel/ Enterprise

The Fat Duck

c) Student

Filipe Leonor

And it is related to the training experience that will take place from the **08/01/14** until **04/04/14**

The goal of this training experience is to grant the student the opportunity to practice all the theoretical knowledge acquired during the school year.

The training experience shall respect the following conditions:

Art. 1- The student's activities will be supervised by the University and by the Hotel.

The representative of the University will be **Dr. João Leitão, Trainee Department Teacher.**

The representative of the Enterprise will be **Sarah Sobo, PA to Head Chef.**

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Escola Superior de Hotelaria e Turismo do Estoril

Art. 2- The training experience will include the performance of the Trainee's tasks on the following areas: **Research & Development, Experimental Kitchen**

The program or the Trainee's tasks will be delivered throughout the training experience.

Art. 3- The student shall obey the internal regulations of the Enterprise and to active the insurance process for eventual incidents. The student shall delivery a copy of the documents to ESHTE internship department.

Art. 4- The Hotel shall provide, during the working hours, the Trainee's meals.

Art. 5- The Hotel shall not provide the Trainee shared accommodation according to the Hotel's premises.

Art. 6- The Trainee shall receive a monthly pocket money compensation of **0** Euros (the placement is unpaid).

Art. 7- The Trainee is entitled to have the same number of days off as the rest of Hotel's staff, **two (2) days off per week.**

Art. 9- The training experience will end on the date mentioned above. If agreed by all parts or in case of disrespect of any of the previous articles of this agreement, the training period could be subject to changes.

Agreeing with what was written above,

ESCOLA SUPERIOR DE HOTELARIA
E TURISMO DO ESTORIL
Gabinete de Estágios / Internship Department
Av. Condes de Barcelona
2769 - 510 Estoril - Portugal

Training Experience's Office – **Dr. João Leitão**

SARAH SEGO

Av. Condes de Barcelona · 2769-510 Estoril · Portugal · Gabinete de Estágios · Tel.: +351-210 040 726/30 · FAX: 351-210 040 719 · www.eshte.pt

eshte

Hotel Representative

Filipe Leonor

Student - Name

Av. Condes de Barcelona - 2769-510 Estoril - Portugal · Gabinete de Estágios - Tel.: +351-210 040 726/30 - FAX: 351-210 040 719 - www.eshte.pt

Appendix 2 – The Michelin Guide

The Michelin guide is the trademark of fine dining restaurants around the world and it means more to professional chefs than most are aware of. The guide is one of the most prestigious in the whole world and a dream come true for any chef and his staff (McConnell, 2014). Michelin guide was first introduced by the Michelin tire company in 1900 (Figure 25). It was supposed to promote tripping around France and it featured restaurants near areas where Michelin had tire shops, people could then enjoy a good meal while their tires were changed (Michelin, 2009).

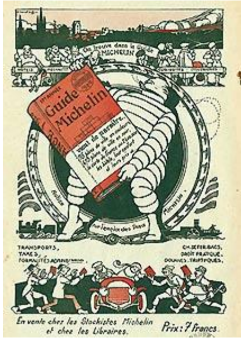


Figure 25 – Michelin guide advertisement. http://www.viamichelin.co.uk/tpl/mag6/art200903/img/saga_Michelin-3.jpg

Today the guide has evolved a lot and is no longer attached to tire shops but only to good food. They have an anonymous network of employees scattered around the globe making several inspections in restaurants. The reviewers then gather and discuss with each other which restaurants deserve to be blessed with stars and those doomed to lose them. The guide is well structured and it has consistent underlined criteria which have to be obeyed in order to get stars. (Colapinto, 2009).

Each year a new guide (Figure 26) is released for each country and restaurants may be awarded with one to three stars as follows:

Figure 26 – Michelin guide. http://www.hotellek2.com/medias/1393336807_guide-michelin-france-2014-jpg.jpg

- One star: A good place to stop on your journey, indicating a very good restaurant in its category, offering cuisine prepared to a consistently high standard.
- Two stars: A restaurant worth a detour, indicating excellent cuisine and skillfully and carefully crafted dishes of outstanding quality.
- Three starts: A restaurant worth a special journey , indicating exceptional cuisine where diners eat extremely well, often superbly. Distinctive dishes are precisely executed, using superlative ingredients (McConnell, 2014).

Although it is still really respected, it is criticized regularly, some believe the Michelin guide still holds and favors restaurants based on French cuisine, style and technique, or towards a snobby, formal dining style rather than a casual environment. Others also suggest it is out of date and favors big name chefs (Colapinto, 2009).

Appendix 3 – The World's 50 Best Restaurants by S.Pellegrino & Acqua Panna

Organized by Restaurant magazine, The World's 50 Best Restaurants (Figure 27) list comes annually and it features the opinions of more than 900 international restaurant industry experts. The "best" is merely achieved by the judgment of these people (Restaurants, 2014).

Contrary to the Michelin guide (and completely independent), there is no pre-determined criteria or check list to be obeyed, therefore a two star restaurant might be ranked 1st in the world's best. The people who vote have in mind more abstract factors, this ranking is more about personal experiences than execution and style (but of course they matter a lot). It is about how the restaurant influences its surroundings, meaning the gastronomic culture of the area which it is introduced (Restaurants, 2014).

Figure 27 – The World's 50 Best Restaurants logo. http://assets.theworlds50best.com/img/logo-w5br.png

The main rules for voting are:

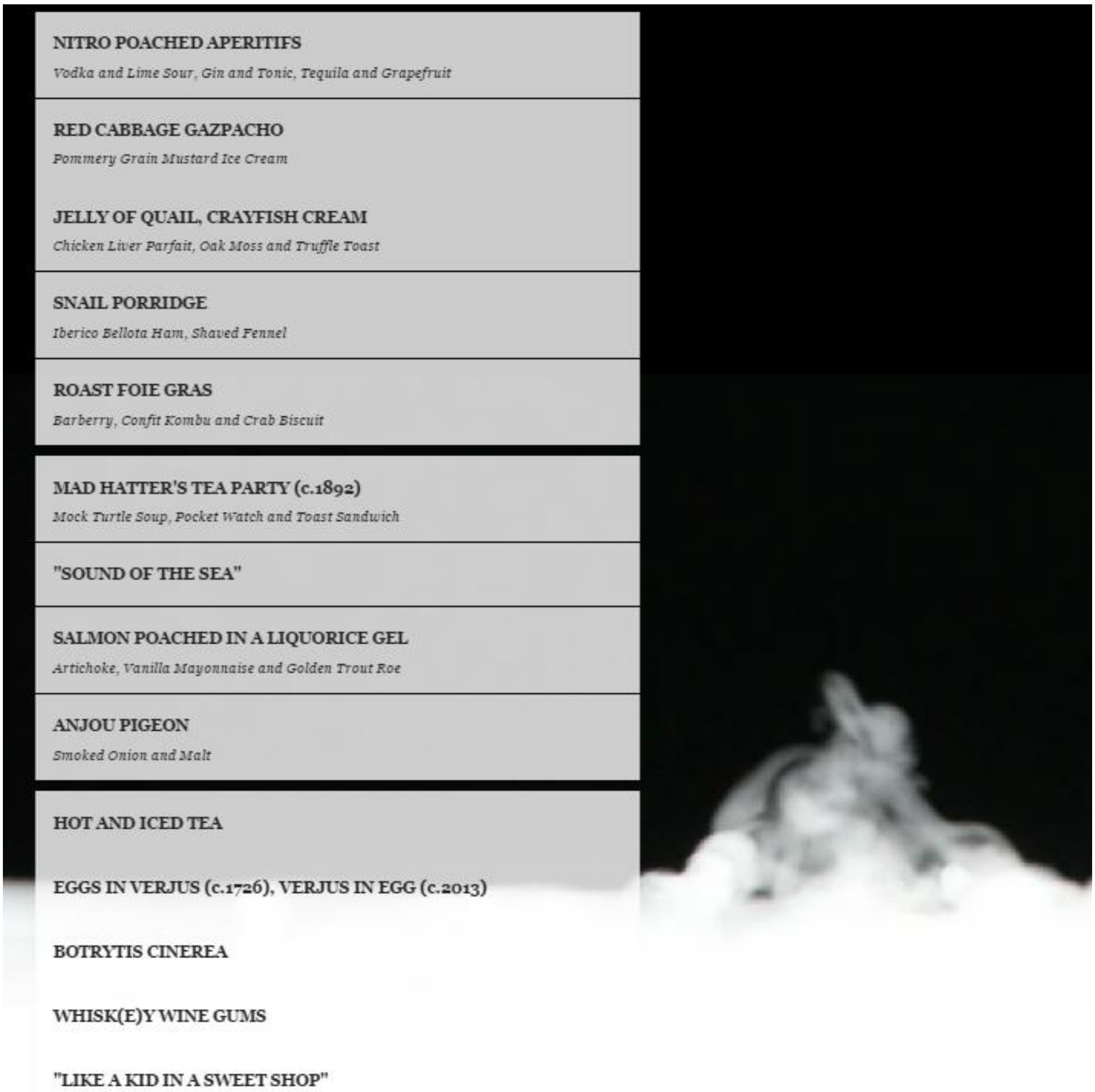
- Voting is strictly confidential before the awards announcement.
- Panelists vote for 7 restaurants, at least 3 must be outside their region.
- Voters must have eaten in the restaurants they own or have an interest in.
- Nominations must be made for restaurant, not for restaurateur or the chef.
- Panelists submit their 7 choices in order of preference (and it is used to decide on positions in the event of a tie) (Restaurants, 2014).

These criteria are designed to allow voters to expand their opinion wide, small and humble restaurants or big and fancy can appear on the list (Restaurants, 2014).

It also means restaurants cannot apply for the list, and cannot be nominated either, no external pressures can influence the list. Most important there are no underline criteria designed to evaluate the restaurant, it is really up to the overall experience they give to the costumer (Restaurants, 2014).

Appendix 4 – The Fat Duck Tasting Menu

The following tasting menu image (Figure 28) is retrieved from the Fat Duck website and it is shows the tasting menu for Autumn, Spring menu has the Pork belly dish instead of Anjou pigeon and the addition of the Rhubarb dish and Black Forest Gateaux in the dessert section.



NITRO POACHED APERITIFS
Vodka and Lime Sour, Gin and Tonic, Tequila and Grapefruit

RED CABBAGE GAZPACHO
Pommery Grain Mustard Ice Cream

JELLY OF QUAIL, CRAYFISH CREAM
Chicken Liver Parfait, Oak Moss and Truffle Toast

SNAIL PORRIDGE
Iberico Bellota Ham, Shaved Fennel

ROAST FOIE GRAS
Barberry, Confit Kombu and Crab Biscuit

MAD HATTER'S TEA PARTY (c.1892)
Mock Turtle Soup, Pocket Watch and Toast Sandwich

"SOUND OF THE SEA"

SALMON POACHED IN A LIQUORICE GEL
Artichoke, Vanilla Mayonnaise and Golden Trout Roe

ANJOU PIGEON
Smoked Onion and Malt

HOT AND ICED TEA

EGGS IN VERJUS (c.1726), VERJUS IN EGG (c.2013)

BOTRYTIS CINEREA

WHISK(E)Y WINE GUMS

"LIKE A KID IN A SWEET SHOP"

Figure 28 – The Fat Duck tasting menu. http://www.thefatduck.co.uk/The-Menus/Tasting-Menu/

Appendix 5 - Equipment

5.1. Centrifuge

Centrifuge (Figure 29) is a high centrifugal machine which separates components of different weights by gravitational force, heavier molecules go to the bottom and the lighter they get, closer to the top they will end.

Figure 29 – Centrifuge. http://www.pocdscientific.com.au/img/eppendorf_centrifuge/eppendorf_centrifuge_5702r.jpg

For instance when tomato juice is centrifuged we end with the solid compounds at the bottom which are essentially cellulose, pectin and heavy pigments, nest layer will be the bilk liquid, rich in sugars, salts, acids and aroma compounds dissolved into the water present in the tomato, and at the top layer a very small amount of froth that is concentrate in natural occurring fatty compounds in the tomato (which taste delicious) (Blumenthal, 2008).

Centrifuging is often used to separate solids from liquids in mixtures such as purées and that would not be possible by other mechanical processes. The liquid has almost all the flavouring compounds and without the solids (which enables foaming) does more stable foams, in addition the result is a finer foam (with little air bubbles), cleaner mouthfeel, cleaner taste and brighter aroma (Myhrvold, et al., 2011).

5.2. Deep Freezer (Polar Bear)

The polar bear is a deep freezer, it has a metal board, which goes down to -80ºC allowing to deep freeze food very quickly, creating small crystals which do not harm so much the structure of sensitive ingredients. It is very good to store expensive ingredients and save their original organoleptic qualities out of their season, good examples are truffles (Blumenthal, 2008).

5.3. Dry Matter Scales

Dry matter in food is essential to a better management of some final products such as potato chips. They need 22,5% dry matter content in order to get a crispy result on the outside and fluffy inside.

To achieve this there is a machine that analyses a piece of food, it has a precision scale and a halogen lamp, which heats the water and evaporates it. The difference between weights is the total of dry matter (Blumenthal, 2008).

5.4. Film Applicator

Film applicator (Figure 30) is a simple device that allows adjusting all 3D of a sheet and it is very handy for precision sheets making (Blumenthal, 2008).

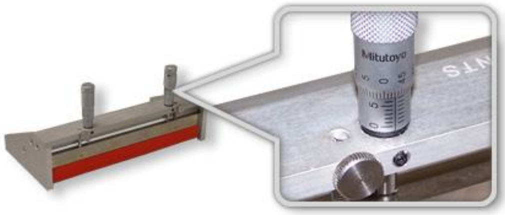


Figure 30 – Film applicator. https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcQZGeLZRoMfdF8MpgHTRyi1PDHRLjvqrhHSijENNYbODqJAbCPn

5.5. Freeze Dryers

Allows flavour concentration for about 99% as it consists in sublimation of water and is made under extreme vacuum conditions.

It is a technique, which can be used to concentrate stocks, however it will not be efficient if the stock is rich in gelatin (it traps water and it will not sublimate). Other possible applications such as solid cocktails served as canapé, fizzy sorbets, etc (Blumenthal, 2008; McGee, 2004).

5.6. Laboratory Balances

To understand why laboratory scales (Figure 31) are so important we first need to understand the concepts of accuracy and precision.

Accuracy is about measuring quantities in the exact weigh desirable.

Figure 31 – Precision scale. https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRC8apVuTsrpn1CU7ekPiPqJTxSKQqEdWgCEDX5wQD992qCA6U

Precision regards to being able to do it every time, over and over again.

Therefore we may be accurate one time but not the other or be precisely wrong the whole time. And laboratory balances help us being not only accurate but precise (Blumenthal, 2008).

5.7. Overhead Stirrers

Overhead stirrers (Figure 32) are not essential but really handy when it comes to mixing hydrocolloids sensitive to Tº or splitting. It allows emulsifying a mixture without incorporating air and it is good for low quantities (Blumenthal, 2008).

Figure 32 – Overhead stirrer. http://www.labpro.co.uk/images/ika-blueline/overhead-stirrers/IKA9003.jpg

5.8. Pressure Cookers

Traditionally concentrated (or reduced) stocks are made by boiling them down. With this method many of the volatile compounds are lost with the steam. We still have the feeling it is much more concentrated – in fact this is because the concentration of heavier molecules such as sugar is higher and sometimes Maillard reaction occurs and helps perceiving it more concentrated, however valuable flavour molecules were lost in the process.

Pressure cookers are semi-sealed vessels and retain much higher amount of volatile compounds, if we let it cool down before opening it, a lot of flavour molecules condense back to the stock (Myhrvold, et al., 2011).

Pressure cookers can be used to heat (at Maillard reaction temperature which is 120ºC) the stock without reaching boiling point, this has the benefit of not causing turbulence and allowing fat to separate and not emulsifying with the stock (resulting in a much clear solution) the downside is that it is not possible to reduce the stock (Blumenthal, 2008).

5.9. pH Meters

They are expensive and hard to maintain, they measure how acidic or alkaline a solution is (it requires it to be at a specific measure to be precise). For instance to have consistency in a dish using cherries, pH meters (Figure 33) will make sure the acidity perception of the dish is the same (Blumenthal, 2008).

Figure 33 – pH meter. https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcSmj1CvdHBhdVBzpnLMAjZCjqBVWIDTF6_hahENvLɑ5LUHUzXkh

5.10. Refractometer

Refractometer (Figure 34) measure the way light bends as it passes from one material to another (phenomena known as refraction). With this device we take a drop of a solution and watch the value is shown at the scale – this value refers to the amount of solute in the solution.

There are many types of refractometers, however in the kitchen the one which scales in % of total solids is the most useful (Myhrvold, et al., 2011; McGee, 2004).

Figure 34 – Refractometer. http://www.blaser.com/pic-html/Usa/refractometer_kombi.jpg

5.11. Rocket Evaporator

The rocket evaporator (Figure 35) is the big brother of the rotary evaporator, the science is the same, however this one is the cutting edge technology in solution reduction. It is so sensitive that it is possible to evaporate water at negative temperatures, this allows food to keep its so precious volatile molecules, evaporating almost only water from the initial solution. Its limitation, just as the rotary evaporator it that they cannot produce Maillard reaction (Myhrvold, et al., 2011).

Figure 35 – Rocket evaporator. http://www.genevac.com/assets/photos/4D_web.jpg

5.12. Rotary Evaporator

Works with vacuum system, the as the solution in the Flask “heats” and evaporates, passes through the condenser and turns to a liquid to a different flask, because it functions under vacuum, water can boil below 100ºC (with 100% vac. – 20ºC). The liquid in the second flask is a solution of water and volatile molecules, meaning it is sort of a perfume of the substance inside the first flask (it has no taste, only flavour). If the system is carefully calibrated it is even possible to extract only essential oils of the solution – they carry very potent flavour molecules (Blumenthal, 2008).

The rotary evaporator (Figure 36) may be used to reduce a solution, however it is hard to only evaporate water, as most of the volatile molecules have lower dispersion point. The reduced solution that remains in the first flask is very rich in heavy and non-volatile molecules (high concentration for taste) but poor in flavour (Myhrvold, et al., 2011).

Figure 36 – Rotary evaporator. http://static.coleparmer.com/large_images/28622_05.jpg

5.13. Sound Box

The ear has fewer sensory cells than any other organ (around 3500), take for instance the eye which has over 100 million. However, scientists have observed that when we were stimulated by a particular sound in early age, we might feel pleasure or disgust according to the memory that sound triggers while we are eating.

The sound box is used in modernist restaurants, for instance at the Fat Duck was used while developing the Sound of the Sea dish (Blumenthal, 2008).

5.14. Thermal Probes

Inexpensive thermal probes are essential tools in the kitchen (basic models have an error or +/- 0,5ºC). However sometimes temperature we may need to record temperature, for instance when cooking a piece of meat for 36h, a bit more expensive probes (Figure 37) are able to record Tº for every minute output a graphic with the information, that way we assure the cooking device did not shut down for a couple of hours and the meat Tº did not go down to dangerous temperatures (McGee, 2004).

Figure 37 – Precision thermometer. http://3.imimg.com/data3/VO/QU/MY-547948/precision-thermometer-250x250.jpg

5.15. Ultra-Low-Temperature Freezers

Concentrated solutions have lower freezing temperature mainly the ones rich in protein in its structure for instance ice cream fully freezes (eutectic state – glass state) at -55ºC and bread only at -70ºC.

At glass state the structure of food is not affected, on the contrary when it is only frozen above its glass state it always causes damage because of ice crystal formation.

This type of equipment is mainly useful for preserving expensive food fresh (harvested in their particular season) when the restaurant wants to use it off season like black truffles. Eutectic state is also useful for enzyme denaturation preventing it to act, a good example is fois-gras which would become pappy if not well-stored.

The faster the freezing process is the better the quality of food is preserved, this happens because there is no time for ice crystal formation therefore no harm to the cell structure (Blumenthal, 2008: McGee, 2004).

5.16. Vacuum Chambers

Can be used for aerating and macerating as it creates vacuum therefore cell expansion enabling liquid to come in and stay trapped when compressed (good for brining).

Texture of fruit and vegetable may be well managed according to amount of vacuum, after compression it may contract resulting in a crunchy texture. Vacuum chambers can also be used to extract liquid from food, drying them.

However, we do not always want certain sensitive ingredients under vacuum, especially if they are at 20ºC, water evaporates and we will lose most of their consistency (Myhrvold, et al., 2011).

5.17. Vacuum Filters

There are a wide variety of forms of vacuum filters (Figure 38), from large pores to very small ones (0,0001 microns) that are used for reverse osmosis.

The larger may be used to make smooth purées, velutées, etc. At 0,1 microns (particles defuse light making the solution cloudy) and under that the result is a clarified stock.

However this is not as good as ice-filtration, many aroma compounds, despite being smaller than the pores, remain trapped in other molecules such as fat, starch, gelatin, etc.

Figure 38 – Vacuum filter. http://www.dartmouth.edu/~chemlab/techniques/graphics/vfiltration/vfiltration1.gif

Aroma filtration is still hard to control (Blumenthal. 2008; Myhrvold, et al., 2011).

5.18. Vacuum Oven

Vacuum oven (Figure39) allow heating in a vacuum controlled environment, there is almost no air left, the heat must be conducted through the metal plates to the food, therefore thinner layers of the product work best but with patience and time, larger products can be dehydrated without burning the bottom (Blumenthal, 2008).

Figure 39 – Vacuum oven. http://static.coleparmer.com/large_images/0505310.jpg

5.19. Water-Baths

Containers with a thermostat which regulate temperature with high precision, they are useful to cook sous-vide technique (Myhrvold, et al., 2011).

Appendix 6 – Ingredients

The following is a list of some of the ingredients used at the Fat Duck which allow achieving certain results, this type of knowledge helps the professional chef to explore the very limits of his own creations.

6.1. Acids and Chelating Agents

Group of substances that can part in gelling processes or texture change, they can even act as a mouthwatering agent.

Chelating agents are chemicals that combine with metal ions such as Ca^{2+} or Mg^{+}, this makes them unavailable for other reactions. In hydrocolloids reactions of jellification, the Ca^{2+} is what makes it happen (triggers and accelerates), to prevent excessive action of the jelling we may add a small amount of sequestrants as sodium citrate or sodium phosphate.

For example vegetables that grow in a very calcium rich soil, when used to make a juice or fluid gel it may become lumpy because of the high amount of Ca^{2+}, in this case it is wise to use a sequestrant (McGee, 2004).

6.1.1. Calcium Chloride

$CaCl_2$ is the molecule and in solid form ions are held in a rigid matrix, however when dissolved the ions can move freely in the solution. Ca^{2+} is particularly good for triggering gelling of many hydrocolloids (because it can form bridges between negative charges), and so for the same reason it can be used to strengthen natural pectin that exists in vegetables call walls which means that adding calcium chloride can prevent veggies and fruits from becoming too soft during cooking. Another application lies on making pasta dough, it can strengthen gluten formation from gliadin and a glutenin protein, the end result is a much more *al dente* pasta. But not everything is good news, use a little too much and food will have an uncomfortable bitter taste (McGee, 2004; Blumenthal, 2008).

6.1.2. Citric Acid

Citric acid is the main acid present in citrus fruit and it is the reason why we can make a tart taste like those fruits. It can act as an antioxidant, therefore it helps preventing rancidity and is used to slow browning of cut fruits or vegetables because high acidity slows enzymatic activity (Blumenthal, 2008).

6.1.3. Malic Acid

Malic acid is the main acid in apples and it is sharper than citric acid, on top of that the tasting sensation seems to last longer.

There are some studies that show malic acid triggers saliva release, therefore food tasted with it may feel juicier (This, 2007).

6.1.4. Sodium Citrate

It is the sodium salt of citric acid and functions as a chelating agent and permits to create solubility that could not happen, as for instance solving cheese in water (incorrectly referred as emulsification). The reaction chelates the calcium present in cheese protein and prevents it to agglomerate, letting it dissolve because it comes apart and disperse (Blumenthal, 2008).

6.1.5. Tartaric Acid

Predominantly found in grapes, it is the acid used to make baking powder and it is slightly sharper than citric acid.

It can be used to gel pectin, the effect is strong and more likely to end with hard texture instead of the fruit jam one. Because it is found naturally in many fruits, when it tasted with beetroot for instance it gives a blackcurrant character (McGee, 2004; This, 2006).

6.2. Dairy Products

Milk is a complex and almost essential ingredient in the kitchen, and because it is so rich has many useful compounds in it like proteins that can make foams. Proteins in the milk prevent foam bubbles from bursting and connecting to each other (McGee, 2004).

6.2.1. Skimmed Milk Powder

Dehydrated non-fat milk containing 54.6% lactose and 36% proteins, very low and almost insignificant % of milk-fat and salt.

High quality skimmed milk is slightly cooked and mildly sweet in flavor with light cream color. Milk powder has been used for a long time, the solution of which will lead to a grainy product because of formation of lactose crystals.

There are different temperatures which can be used to dehydrate milk into powder, low, medium and high. High temperatures lead to a powder that can improve body and texture of an ice-cream while low temperature dehydrated milk can confer a pleasant milky character (McGee, 2004; Félix 2012).

6.2.2. Sodium Caseinade

It is a protein present in milk which ions of Ca^{2+} have been changed into Na^{+}, this is a good protein source and it is the protein in cheese.

Sodium caseinade can come handy in ice-cream to increase solid content and helping with emulsification and foam stabilization (Blumenthal, 2008).

6.3. Emulsifiers

When two substances do not mix chefs may use emulsifiers to bind them together (Blumenthal, 2008).

6.3.1. Lecithin

It is a complex protein which is composed by a mixture of phospholipids, used in industry to make chocolate more tolerant to water, if added too much to liquid chocolate the result will be lumpy.

In watery solutions lecithin improves they foaming capacities, it coats air droplets and usage goes from 0.1%-1% (MgGee, 2004; Félix, 2012).

6.4. Enzymes

Proteins that act as a catalyst and can make the reactions happen without changing their structure, these reactions usually occur at ambient temperature. Nevertheless being proteins they can be denatured by heat, dehydration or pH extremes and lose their function.

Enzymes can be used in a lot of ways, to tenderize a tough cut of meat, to stick two pieces with protein structure together or even break down starch into maltodextrin, glucose syrup, glucose or maltose.

They have been used for a long time on making cheese, bread and fermented beverages, however they are not always useful therefore they need to be controlled, for instance if we add them in pineapple or kiwi juice gelatin it will be break down and come never set because of the acting of a specific enzyme, on the other hand this will not happen in canned pineapple because the enzyme has been denatured by temperature (McGee, 2004, Myhrvold, et al., 2011).

6.4.1. Invertase

An enzyme which acts specifically to break down sugar molecules, turning them into individually glucose molecules (inverted sugar). This comes handy for instance when we want to make a bonbon liquid inside such as After Eight, the coating is done on solid mint flavoured fondant together with Invertase and after 7-8 says it has turned into a paste or liquid depending on the amount of enzyme used (Grewling, 2013).

6.4.2. Transglutaminase

Known as Activa, a specific group of enzymes that catalyze bonding between the amino acid lysine and glutamine. Transglutaminase can be used to bind meats and may also strengthen gluten bonds in noodles, however it tends to toughen meat therefor it is crucial to use just the right amount in meat and fish (McGee, 2004).

6.5. Hydrocolloids

They are large chain molecules (polysaccharides) that may come from various sources, usually having a sugar structure but protein-like structure exists too. On a chef's point of view, they are useful for stabilizing, thickening or gelling a solution (Blumenthal, 2008). Hydrocolloids are hydrophilic, they disperse in water and depending on its amount, results can be a liquid or solid solution (Britannica, 2013).

Hydrocolloids are categorized by their structure, linear or branched and charge, neutral or charged, when carrying small negative electrical charges (Table 4) (Blumenthal, 2008):

Polysaccharide	**Structure**	**Charge**
Amylose starch	Linear	Neutral
Methylcellulose	Linear	Neutral
Agar	Linear	Charged
Gellan	Linear	Charged
Pectin	Linear	Charged
Xanthan gum	Linear	Charged
Amylopectin starch	Branched	Neutral
Gum arabic	Branched	Charged

Table 4 – Hydrocolloids organized by structure and electrical charge (Blumenthal, 2008).

A linear structured polysaccharide will thicken a solution more efficiently because the molecule is simpler and entangles water easily, however the branched structured are more soluble in water meaning that they can be used in high concentrations without saturating, in addition some of these have unique properties as gum Arabic that can emulsify some sensitive oils as essential oils on beverages (McGee, On Food and Cooking: An Encyclopedia of Kitchen Science, History and Culture, 2004).

Charged polysaccharides interact with charged metal ions as calcium and magnesium, this forms links between molecules therefore gelling, it is important to analyze the type of water used for charged hydrocolloids because tap water is mineralized and it will have direct effect on the reaction, a good way to control the gelling reaction is to use deionized water (Blumenthal, 2008).

This type of product revolutionized the modernist cooking, they permitted new textures and new appliances never seen before, nowadays they can be found in almost every modernist kitchen (Moura, 2011).

6.5.1. Agar

It is obtained from red seaweeds from the class *Rhodophycaea*. Agar forms clear and very brittle gels after hydration and cooling down, unlike other hydrocolloids (apart from Gellan) it has the unique characteristic of forming a fluid gel when blended after cooling. It starts setting between 32ºC and 40ºC and will not re-melt until heated generally above 95ºC, it is used in low amounts such as 0,5% to 2% of the solution weight (Blumenthal, 2008; Félix, 2012).

6.5.2. Gellan F

Low-acyl and once set melts at higher temperatures than water, in practice it means once set it cannot re-melt again. It sets into a very brittle and clear form and it is very sensitive to salts, and acids. And the overall result will be different even for different season products (Blumenthal, 2008).

6.5.3. LT100

High-acyl and once set it melts at temperatures around 75ºC, it has similar structure to Gellan F however it sets into an opaque and more elastic form. Because it is not as sensitive to salts and acids as Gellan F it is best to use when gelling dairy products (Blumenthal, 2008).

6.5.4. Pectin

Molecule found in almost every land based-plants. It has structural functions and acts as cement between the cellulose walls, commercially extracted under light acidic conditions from citrus peel or apple (the foam that results after juicing apple) it is then concentrated, purified and precipitated by adding alcohol (Blumenthal, 2008).

Pectin is a polysaccharide, sugar polymer that is classified according to size and range, it contains many exposed oxygen and hydrogen atoms meaning it can form bonds and absorb water, however they have attractive forces between the polymers themselves and when an network is formed they cannot dissolve in water (McGee, 2004), the network is needed for the jelly to set, when heated these bonds are undone and the solution liquefies, however, low the temperature again and you promote the perfect environment for bounds to take place again. The molecule consists of hexagonal linear chains with five carbon and one oxygen atom in each, they can bear COOH acid groups capable of ionizing (This, 2007), some of the links carry methyl ester group, the number of methyl ester groups in a molecule of pectin translates the degree of esterification, which is related to the gelling point and its texture. Natural pectin esterifies in about 83%, however in industry this point may be reduced or even completely eliminated, pectin with high esterification (high-methoxyl pectin such as Pectin Jaune Yellow) will need low pH conditions (2.5 to 3.8) and a sugar/salt concentrated solution (about 55%) to effectively esterify, which is fine for acidic jellies and jams (like lemon). On the other hand, for flavors that are not acidic such as certain flours it is advised to use a low-methoxyl pectin (Pectin NH Nappage) that esterifies in a large range of pH and low solids concentrated solutions, the problem with this one is that it needs calcium ions to be present in the solution for it to gel, in natural juices there is more than enough calcium, on products poor on it, calcium chloride can be added to achieve the desired Ca^{2+} concentration (McGee, 2004).

One reason for using pectin to make jellies is that it breaks down really easy in the mouth so it has a great flavor release, however the amount of solids needs to be controlled before adding the acid for it to act properly (a refractometer will measure the amount of sugar in the solution) (Blumenthal, 2008), one should have in mind that the amount of pectin used must be thought properly, too much and the final texture can be heavy, sticky and will trap many of the volatile compounds resulting in a much tasteless jelly (This, 2006).

6.6. Sweeteners

Usually monosaccharide that is capable of giving sweet sensation to the solution, different sugars have distinct relative sweetness according to sucrose (Table 5) (Blumenthal, 2008):

Sweetener	Relative Sweetness
Sucrose	1.00
Glucose	0.76
Fructose	1.52
Galactose	0.50
Mannose	0.45
Maltose	0.45
Lactose	0.33
Raffinose	0.22
Sodium cyclamate	30
Glycyrrhizin	30-50
Acesulphame K	140
Aspartame	200
Saccharin	350

Neohesperidin dihydrochalcone	1000
Perillaldehyde antioxime	2000
1-n-propoxy-2-amino-4-nitrobenzene	4000
Xylitol	1.00
Isomalt	0.50
Sorbitol	0.50
Lactitol	0.50
Lycasin	0.75

Table 5 – Different sugars and their relative sweetness compered to sucrose (Blumenthal, 2008).

Sugars have different molecular weights, which is determined by the Dextrose Equivalent (DE), according to the number of glucose molecules at one end of the chain of the that particular molecule, compared with the number of glucose molecules at one end of the chain of a pure glucose molecule x 100, meaning the DE refers to the percentage of the number of glucose molecules present in a chain of a particular molecule compared to a pure glucose one. Also, logically DE 10 is lighter than a DE 20. (J. A. Wilson, 1995).

6.6.1. Fructose

It's the natural sugar present in fruit and honey, it is 1,52x sweeter than sucrose. When used for sweetening fruits, it gives a boost of natural flavor and enhances fruitiness (Blumenthal, 2008).

Fructose can be used by yeast in anabolic conditions for fermentation (McWilliams, 2013) and promotes Maillard reaction in an early stage since it exists to a greater extent in the open chain than glucose, this means that fructose may have an important role on non-enzymatic browning (Jr, 1993).

6.6.2. Glucose

The most important sugar in biology, it is the easiest way which every organism can take energy from. It can be extracted from plants, from their cellulose walls by hydrolyzing and separating it in multiple glucose molecules.

It is possible to produce two types of glucose, L-glucose (not digestible by organisms) or D-glucose (natural form found in nature and the only one used in food, many times referred as Dextrose).

Glucose syrup results from the hydrolyze of corn starch, stopped in middle process.

There are many different applications for glucose, for instance in ice cream to prevent crystallization and promote stability, however there are some glucose syrups that still might have some existent starch and this can trap flavor release (Grewling, 2013).

6.6.3. Sucrose

Sucrose can be made to have smaller or larger crystals depending on the manufacturer. Smaller sucrose crystals melt easily to make a caramel so they are good for browning a crème brulée, larger ones melt slowly but have high capacity of trapping water and fat, this can help the chef beating sugar with butter, it traps moisture and air bubbles preventing the solution to split, scenario that would otherwise happen if a small crystal sucrose was used (Grewling, 2013; McGee, 2004).

6.6.4. Maltodextrin

It is achieved the same way glucose is, breaking down chemically or by enzymatic processes to shorter dextrin molecules, the process for maltodextrin is stopped usually between DE 2 (nearly pure starch) and DE 20 (nearly confectioner's glucose syrup). Maltodextrin is then spray dried and the final product is sold as a powder for easier application (McGee, 2004).

This starch is different from others and some types (such as the N Zorbit M) which have the unique ability of absorbing fat and certain amounts of liquid, if it is the correct amount we end with a powder flavoured with of the solution added (example: sand or the Sound of the Sea dish) (Blumenthal, 2008; Félix, 2012).

Appendix 7 – Techniques

The following shows and explains some of the techniques used at the Fat Duck, some I discovered and had the opportunity to apply during my time at the lab (see Appendix 10), others while observing and questioning the preparation and service staff.

7.1. Deionization

It is essential to have nonionic water (with no salts or electrical charges whatsoever) when working with hydrocolloids as they are commonly affected in their performance (thickening power) by the presence of calcium or magnesium which exist in tap water.

There are several processes of making deionized water such as reverse osmosis or cheaper methods like plastic beads (chain necklace) which react with metal ions and take them out of the solution (McGee, 2004).

7.2. Dry Ice

Dry ice is frozen CO_2, it does not melt but sublimates at 78,9ºC, it has the ability to carry aroma in the form of vapor (because it is so cold, dispersion rate is low for volatile molecules).

CO_2 is toxic for the body and we perceive it by a fizzy sensation (with some pain), the same sensation we feel when drinking beer or soda. Adding dry ice to certain types of ingredients for instance fruit can make them fizzy and keep their freshness at the same time (example: dry ice + orange = fresh fanta).

Another good use for dry ice is on making ice cream, it becomes a little fizzy too and the low temperature enables small crystals to form, resulting in a better and smoother texture, also, because the mixture becomes really cold, small bubbles of CO2 become trapped in the ice cream making it even lighter (Myhrvold, et al., 2011; Blumenthal, 2008).

7.3. Fluid Gels

Fluid gel is a stage when a solution is not either a solid nor it is a liquid, ketchup is a good example of a fluid gel, when still it acts as a solid and does not move, however when a force is applied it deforms the same way a liquid does.

Fluid gels have very good flavour release because they are easily broken down by saliva and the technique is simple, a specific hydrocolloid (agar or from Gellan family) is added to the solution, brought to a boil to disperse into it and then cooled down to set.

When agar or Gellan start setting they create a brittle substance, however if blended they will transform into a fluid gel and will stay that way unless they heated again at temperatures high enough to melt the gelling agent again (Myhrvold, et al., 2011).

There is a bit of a controversy about the process of making fluid gels, should we add the gelling agent in a cool solution and then bring it to a boil or just add it when the solution it at the required temperature? There is no scientific proof of which one is the best, however it seems it is easier to add it while the solution is hot and blend it right away. Adding while it is still cold might stick part of it to the bottom while cooking and disturb the ratio added (which is very important since we work with very small amounts 0,5%-2%).

Another factor to consider is to blend it when completely cold or while it is cooling down and again, there is no right answer. Blending while cooling down seems to be easier and adds less air bubbles to the solution, however if a fluid gel has bubbles because of the blending process and it is not completely clear, it can be put inside a vacuum chamber machine and decompress all the air.

Most fluid gels can be heated up again to around 80-85ºC without melting and the potential for the professional chef is high (Blumenthal, 2008).

7.4. Ice Cream Science

The true origin of ice cream is still unknown, however experts know it were the Italians who popularized it not only around Europe and the rest of the world.

Ice cream has perfect physical structure to give us satisfaction when eating it because our body perceives it as food (sugar, fat and proteins) but also a drink (being served cool and melting into a liquid in our mouth).

Proper ice-cream will have on its structure:

- Fat: It is important for stability however not always desirable. Ice cream full of fat will be more stable but will make flavour release slower and longer in time, on the other hand low content ice cream will allow high bursts of flavour which last less but give intense sensation
- Milk solids, not fat (MSNF): Help in stability of fat droplets and incorporation of air during churning (because of foaming properties of proteins). Too much MSNF and the ice cream will end too aerated and low flavour concentration, however with low MSNF content it will be very unstable.

- Sugars: There are many different sugars, and all of them give bulk to the mixture. They also influence freezing temperature – which is determined by the number of molecules dissolved in water, more substances will result in lower freezing point.

  Different sugars have various influences, for instance one kilo of sucrose (glucose + fructose) has a certain effect on the freezing point other than glucose or fructose (which will have twice the effect since they are half the molecular weight).

  They also have different sweetness intensities (see Appendix 5) for instance glucose is 80% as sweet as sucrose and fructose is 140%.

  Sugar will make the ice cream softer at certain temperatures but it seems to hide flavour and slower its release.
- Emulsifiers: Act to bind two things which naturally would not mix (for instance water and oil), in ice cream it egg yolk (with lecithin) is commonly used, however it has only 1% of stabilizing function. In industrial produced ice cream, egg yolk is substituted by mono-diglycerids.
- Stabilizers: As the name suggests, they give structure and stabilize the ice cream preventing it from melting too quickly and also inhibit water crystal formation during freezing.

  There are many types used (usually gelatin and gels), manufactures have already developed blends of several ingredients, however in the professional business chefs tend not to use stabilizers because they trap flavour molecules, which makes difficult their release (Blumenthal, 2008; Félix, 2012).

7.4.1. Making the Mix

Before even thinking of producing ice cream it is necessary to develop a recipe with appropriate amounts of each structural component – which will be discussed later.

An important part of making the mix is to pasteurize it (warming up to 80ºC), this not only makes bacteria to die but also allows fat droplets to disperse in the water phase. With fat melting into oil, it tends to bind together with the solution (with the help of the emulsifiers) and this step is crucial to achieve small fat droplets.

Next step is to cool it down to refrigeration temperature (4ºC), fat solidifies at this temperature and can no longer aggregate again, aging the mixture is also necessary and it should take between 8-24 hours. Aging helps protein from milk to coat fat droplets and help stabilize them within the watery solution. During churning these coated fat droplets are released once more (the mechanic work breaks the milk proteins down), however with the help of emulsifiers these coating will be redone but only if already existed before churning, that is why maturation of the mix is so important before churning (Blumenthal, 2008; Félix, 2012).

7.4.2. Freezing Process

Commercially the process takes place in a refrigerated tube which is refrigerated by liquid and scooped inside with a paddle or a blade, the mix comes in one side and goes out the other at -5ºC and no more – for the fact that at this temperature the amount of energy needed to take the heat out of the mixture is equal to the one transferred from the churning blade into it. The ice cream should then be deep frozen at -35ºC (temperature in which sugars take glass form and trap everything in it).

Other techniques can be used for freezing, such as deep freeze the mixture right away (develops large crystals) and then churn it in a machine called Paco-jet, the extremely potent blending is enough to incorporate air (overrun) and grind the large crystals into smaller ones for smoother texture, however the ice cream tends to have high overrun and feel airy.

Liquid nitrogen or dry ice may be used as well, whisking and the very fast freezing allow small crystals to form and (in the case of dry ice) more air is incorporated into the ice cream meaning better overrun (Blumenthal, 2008; Félix, 2012).

7.4.3. Finding Appropriate Amount of Core Ingredients

A good ice cream has carefully calculated amounts of each core ingredient in order to achieve the best organoleptic characteristics. However, what is shown below are just guidelines of basic creations for each type of ice cream (Table 6), chefs use this knowledge as a starting point to achieve the results they have in mind.

Style	Total Solids %	Sugar %	MSNF %	Fat %
Very rich, premium	40-46	15-17	7-9	16-20
Ice cream	35-42	13,5-18	10-12	10-14
Gelato	32-42	14-24	8-11	3-8
Soft serve	30-38	14-18	11-13	4-6
Milkshake	25-30	9-14	11-13	3,5-4,5
Sherbet	32-38	28-34	2-5	1-2
Sorbet	26-34	24-30	0	0

Table 6 – Appropriate amounts of core ingredients required for particular styles of ice cream (Blumenthal, 2008).

Next is a good example of a possible exercise for a base vanilla ice cream to reach the percentages needed (Table 7). The amounts of structural components of each ingredient may be coded to a database and developed into a working sheet to make the calculations easier – as for instance (Figure 40) – Data base developed during the Internship by the author.

Ingredient	Weight (g)	Total solids (g)	Sugar (g)	MSNF (g)	Fat (g)
Whole milk	1000	125	0	87	38
Whipping cream	47	19,3	0	2,8	19,3
Skimmed milk powder	63	61,1	0	60,7	0,4
Egg yolks	200	102	0	0	98
Unrefined sugar	200	200	200	0	0
Vanilla beans	8 beans	-	-	-	-
Coffee beans	3 beans	-	-	-	-
Totals	1510	507,4	200	150,5	155,7
Percentages	100	33,6	13,2	10	10,3

Table 7 – Vanilla ice cream base recipe made by adjusting the percentages of individual structural components needed for ice cream (Blumenthal, 2008).

7.4.4. Developed Ice Cream Equilibrium Database

Ingredients	Amount	Sugars	Fat	N.F.M.S.	Water	Total Solids
Water					0	0
Whole Milk			0	0	0	0
Semi-skimmed Milk			0	0	0	0
Skimmed Milk			0	0	0	0
Cream 35% fat			0	0	0	0
Milk powder 0% fat				0	0	0
Dextrose		0			0	0
Caster Sugar		0			0	0
Glucose		0			0	0
Fructose		0			0	0
Egg yolk			0		0	0
Cocoa power			0		0	0
Chcocolate 70%		0	0		0	0
Chocolate 65%		0	0		0	0
Chocolate 60%		0	0		0	0
Chocolate 55%		0	0		0	0
Milk Chocolate 40%		0	0	0	0	0
White Chocolate		0	0	0	0	0
Hazelnut paste			0		0	0
Almond paste			0		0	0
Nut paste			0		0	0
Lemon juice		0			0	0
Lime juice		0			0	0
Orange juice		0			0	0
Apricot		0			0	0
Peach		0			0	0
Strawberry		0			0	0
Mango		0			0	0
Rasberry		0			0	0
Blackberry		0			0	0
Cherry		0			0	0
Total (g)	0	0,0	0,0	0,0	0,0	0,0
Total (%)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Ice cream (-11 to -14)		**13,5-18%**	**10-14%**	**10-12%**	**58-68%**	**35-42%**
Sorbets (-11 to -14)		**24-30%**	**0%**	**0%**	**62-72%**	**26-34%**

Figure 40 – Ice cream equilibrium database screen shot – developed during the internship by the author.

7.5. Ice Filtration

It is a unique technique used to filter a stock or juices and has more benefits than the traditional clarification method. It consists of freezing the solution (which was added 5% gelatin) and then place it in between a perforated tray and muslin cloth, letting it defrost over night between 0-4ºC (Blumenthal, 2008).

Advantages: Fat does not melt therefore the resulting liquid will be clear and transparent (being fat the main responsible for cloudy stocks). Not all ice crystals melt at the same temperature, the first ones contain sugars, salts and flavour molecules, the last ones melting are the pure ice crystals (which are not of great interest) and they get trapped in the gelatin network we created before freezing. The stock not only concentrates but it does without the need of heat.

Disadvantages: Fat contains valuable flavour molecules. The final product does not contain any gelatin in it and to thicken it again will become cloudy. However this problem is solved using texture agents such as Gellan F to create a fluid gel (McGee, 2004; Myhrvold, et al., 2011).

7.6. Liquid Nitrogen

Boils at -196ºC and is a great way to freeze food under its eutectic Tº (phenomena of water crystalizing into glass form, trapping everything in it and not allowing any kind of reaction to happen). It has the downside of being overpriced (depending on the amount used) (Myhrvold, et al., 2011).

7.7. Slow Cooking – Meat Science

Meat is structured by three main components, muscle fiber, collagen (connective tissue) and lipid.

Muscle fiber is composed of the proteins actin and myosin, they are both responsible for muscle contraction. After slaughter, Ca^{2+} travels freely through meat activating the actin-myosin bonding. At this stage there is muscle contraction (rigor mortis).

For the meat to become tender, we have to give it enough time to enzymes such as calpain (which works in specific proteins, leaving muscle fibers intact) to break down actin-myosin bonding – maturation of meat. if the maturation process is long enough, more than 18 days (the maximum amount of time calpain usually acts), we call it aging and it will allow water to evaporate and concentrate flavours of the meat.

Connective tissue is the most abundant protein in animals, it is a fibrous structure which tangles together and surrounds muscle fibers – more powerful muscles require greater amounts of collagen in its structure.

It strengthens with aging of the animal, which means younger specimens tend to have tender meat. However, genetically modified species formatted to have well distributed collagen may have tender meat despite the age of the animal.

Collagen distribution also depends on the type of growth, slow production have better distributed collagen in the muscle.

When collagen denatures by heat, it breaks down and becomes gelatin and this phenomena gives moister to the meat.

Lipid gives moister sensation and mouthfeel to meat and it contains valuable fat soluble molecules regarding to the type of meat we are eating, and it has also as a role to play in the Maillard reaction in cooking.

There are other molecules in meat such as myoglobin (responsible for the red color) and glycogen (power source in actin movement) – during slaughter, the more stressed the animal is the more glycogen it spends in muscle contraction, therefore actin-myosin molecules will become more contracted resulting in tougher meat.

Ribose for instance is a very important molecule cooking speaking, it is a reductive sugar and enters in the Maillard reaction, which develops meaty flavours and allows the formation of crust.

Meat also has vitamin B1 or Thiamin, it contains sulphur atom and when heated, it helps breaking down other molecules and creating the flavours of cooked meat, and that is why it is so important to add onion and garlic when making stews, they too have shulphur atom in their structural molecules (McGee, 2004; Roca & Brugués, 2014; Blumenthal, 2008).

7.7.1. Cooking

Cooking process starts at 38ºC, actin and myosin begin to denature and toughens, however this particular hardening allows an easier break down during chewing as some enzymes are now more active.

At 55ºC water will start slowly leaking from the cut ends, the contractile protein coagulate and harden causing more water to come out. Therefore meat is vulnerable to water loss at this point while protein contraction is occurring.

Still at 55ºC, collagen contracts and squeezing even more water from meat, at 65ºC protein contraction is on its peak and finishes right after that, further heating will only extract water and make the cut seem dry and though.

However, if collagen is heated in the presence of water it breaks down into gelatin which is has the ability to retain water.

When braising meat, if it is quick, not much of the collagen comes out of the piece of meat, nevertheless if we boil it for a long time gelatin comes out to the water (which is exactly what we want when making stocks – to give body and flavour).

For instance in cooking meat sous-vide, searing prevents oxidation of most fats and flavour molecules, bacteria are killed at such temperatures and will not infect anyone who eats it and also can not affect flavour (for example in the case lacto bacteria develops flavour will be compromised).

Sous-vide has really high potential and allows the professional chef to achieve amazing results on texture, juiciness and flavour in meat, it has some limitations – roast flavours cannot be developed nor any kind of Maillard reaction (at least during cooking), however, the cut can be seared before or after cooking or juices from a roast can be added to the bag. When cooking meat sous-vide for better retaining juices (because there are always some which come out) and better maturation of flavour, after cooking a chilling process can be made following these steps: chill still in the bag in water at room temperature for 15 minutes, pass to water at 8-10ºC for another 15 minutes and after that in ice-water for 2 hours, lastly refrigerate at 4ºC for at least 24 hours. This process not only allows juices to go back inside the cooked piece but flavours to mature as well as tenderness for the fact some enzymes did not denature and are still active.

On the down-side not all meat is good for cooking sous-vide, because it happens at temperatures where enzymatic work is at its peak, several types of meat such as rabbit, lobster, langoustine, shellfish, and others will get pappy texture if not careful controlled. This can be solved by doing two cooking phases the first at a temperature high enough to denature enzyme in a short time period, and the second to actually cook the meat in values which will not be so high that otherwise would over-cook it.

Salting meat and making soft brines between 3-12% salt by total weight by helps achieving better results, not only we eliminate the possibility of over salting the meat but we help achieving juicier results. Salt penetrates the meat by osmosis and it denatures myosin (not allowing actin-myosin to form), the brie itself is now able to dissolve on the myofibrils filament and breaks them down (opposite effect of rigor-mortis which is similar to maturation). After that, myofibrils swell with the brine making them juicier and tender, this effect has better performance when the meat is cooked, it forms a gel similar to gelatine from collagen which promotes even more water retention.

Cooking a steak at 56ºC and making a nice crust (Maillard reaction) will allow the piece to retain around 70% of the juices inside, the result is a very rich meaty flavour due to Maillard reaction and tender moist inside meat (McGee, 2004; Roca & Brugués, 2014; Blumenthal, 2008).

7.8. Sous-vide

Cooking in vacuum-sealed bag inside a carefully controlled water-bath which regulates temperature. This is a really precise cooking technique that protests the integrity of the ingredient, organoleptic and nutritionally speaking.

The vacuum bag as well as the ingredients must be well disinfected as cooking sous-vide we work in temperatures which promote bacteria development. One of the first uses of this technique was to cook Fois-gras, because it is very expensive and by cooking sous-vide it was possible to retain 70% more of the total weight, and also it comes out perfect every single time.

However it was not all easy, enzymes in the liver start self-destruction of small membranes right after slaughter. They can be stopped by nitro-freezing process which forms almost only small ice crystals, and does not damage as much the liver.

Other factor for pappy texture of fois-gras when cooking sous-vide is the fat, it can have two types of distribution:

- Macro-vesicular steatosis: large vacuoles filled with fat and give much of the oiled sensation when chewed, therefore pappy texture sensation.
- Micro-vesicular steatosis: small vacuoles filled with fat which liberate small amounts of oil when chewed and give much more consistent texture sensation.

High quality and low quality Fois-gras both have the two kinds of fat, however it is more common to see macro-vesicular steatosis in mass productions and micro-vesicular steatosis in extensive ones (Roca & Brugués, 2014; Blumenthal, 2008).

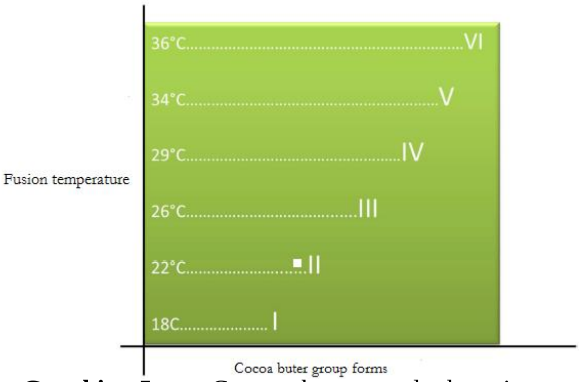
7.9. Tempering – Chocolate Science

The tempering technique was developed in industry to make chocolate stable at room temperature – not melting when we grab it, also it appears shiny and crispy when chewed. Tempering regards to temperature and it consists in changing chocolate temperature up and down in order to form stable cocoa butter crystals.

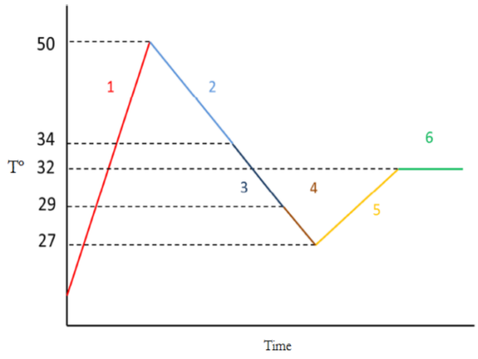
Cocoa butter is one of the core components of chocolate and is probably the most important. We know it is polyphorm meaning it can take many forms (without changing much in a molecular way), there are six groups related to cocoa utter polyphormism, each type of molecule has its own and different fusion temperature point – temperature in which it passes from solid to a liquid (Graphic 5).

Only both groups V and VI are crystals in stable form and to achieve better tempering we have to play with temperature to create them and as less as possible from the remaining groups.

Chocolate both from industry is already tempered, however because it is in solid form chefs cannot mold it freely, when melted it will become unstable again and the tempering technique is required (Graphic 6).



Graphic 5 – Cocoa butter polyphormism (Grewling, 2013).



Graphic 6 – Time, temperature and stages relation for dark chocolate tempering (Grewling, 2013).

Starting at room temperature (1), we melt the chocolate usually to 50ºC (above this temperature the little water it has may evaporate and chocolate becomes sandy and is ruined), at this temperature all crystals are melted. We start cooling it down always agitating (factor that promotes crystal formation) until it reaches 34ºC (2), here both groups of stable crystals are formed but to make sure all of stable crystals are formed we let the temperature down below to 27ºC (3) and (4). However this means some unstable groups crystals started to form, to melt them again we raise the temperature again to 32ºC (5), this is enough to melt crystals all the way up to group IV but not group V, we have just assured all unstable crystals are melt and stable are formed and the chocolate is ready to be used, this temperature (chocolate working temperature) can be maintained for a long time (6). Temperatures shown are for dark chocolate only, because milk and white chocolate have other ingredients in their composition, tempering temperatures are less 2ºC and 3ºC, accordingly (Grewling, 2013).

Appendix 8 – *Sound of the Sea* Detailed Information

Sound of the Sea (2007)

The dish is served on bespoke plates made from walnut wood.

The conch shell contains a music player (containing sounds of the seashore), and is placed in front of the costumers giving them enough time to get the headphones in their ears to create context before the dish is served. (Figure 41).

Figure 41 – Sound of the Sea dish. http://www.bristol.ac.uk/centenary/images/recipe-finished.jpg

Main Components:

- Sand – made with cod liver oil, panko miso, and maltodextrin;
- Sea – a seaweed broth and lecithin (later aerated with a hand blender);
- Seaweed plants;
- Ponzu – classic Japanese sauce very rich in umami, made with sake, fresh yuzu juice, katso bushi and kombu;
- Fish – currently three types of cured fish.

Concept:

This dish started being developed as the result of Heston Blumenthal's interest in the link between sound, context and nostalgia on flavour perception. With the help of Dr. Charles Spence the fat duck team began experimenting with oysters and peoples' perception of their flavor depending on what they were listening to. The experiment showed that listening to the sound of the sea made the oyster taste better and even saltier than when listening to barnyard noises; however both oysters were the same (Spence, 2008).

One can assume by these findings that when a contextual memory is provided for several individuals, they are able to make their own interpretation of that memory (Verhagen & Engelen, 2006). If, for instance a picture of a seaside was to be shown, it would be too specific and prevent the diners from mapping their own sensory image in the orbitofrontal cortex (Shepherd, 2013). Theoretically this allows the experience to be cross cultural and not effected by language. Although it can be limiting because the costumer has to already have had seaside memories banked in their brain (Prescott, 2008).

Appendix 9 – Top View of the Fat Duck

The Fat Duck's address is SL6 2AQ, High Street in Bray, Berkshire, United Kingdom and it has several infrastructures. The food is prepared at the preparation house and sent to the service kitchen in appropriate boxes. Development kitchens are at the preparation house top floor and at the canteen building (Figure 42).

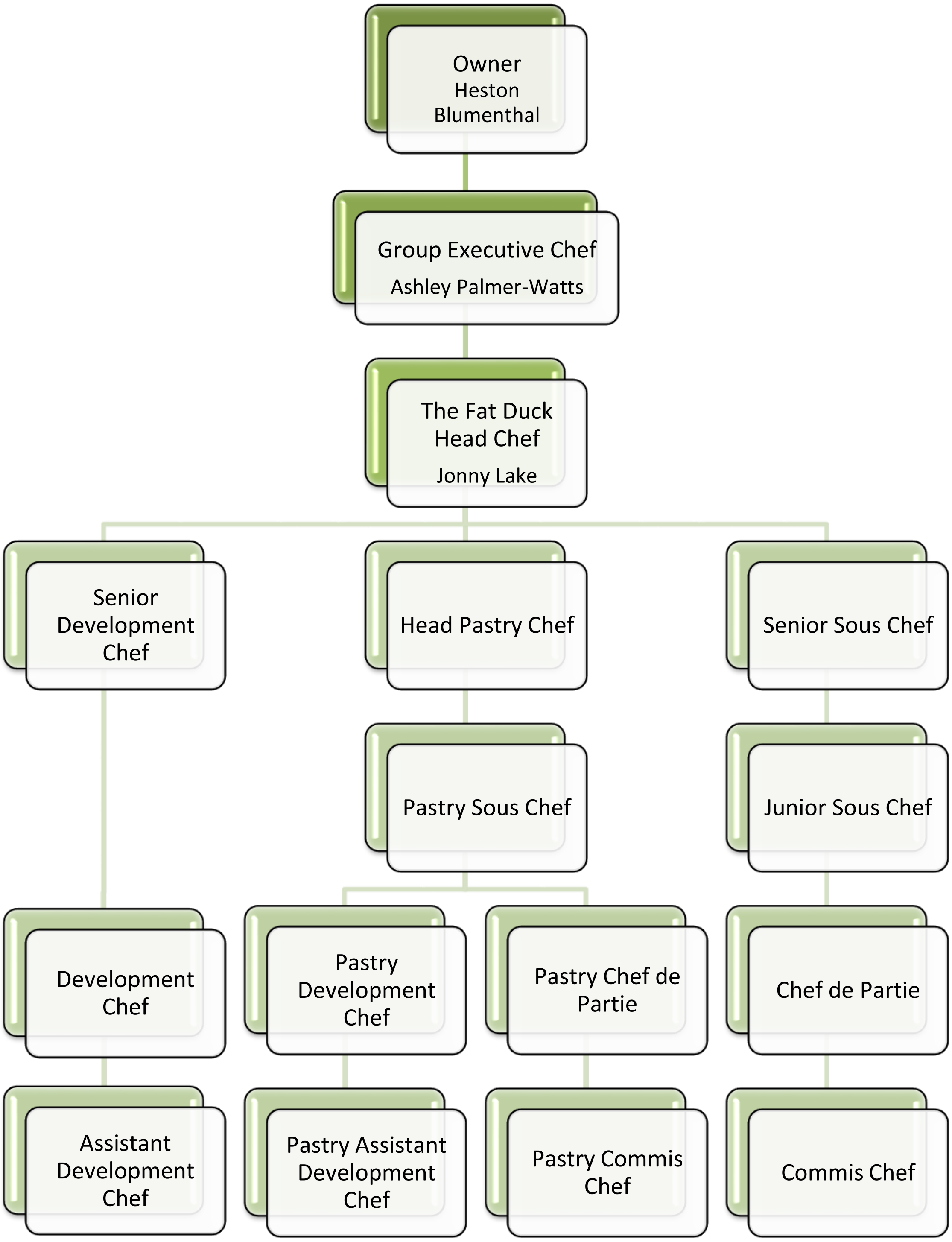
Figure 42 – Top view of the Fat Duck. https://www.google.pt/maps/place/The+Fat+Duck

1 – The Fat Duck Restaurant and service kitchen.

2 – Canteen, pastry laboratory and offices.

3 – Preparation kitchen and pastry, reception of goods and main laboratory

Appendix 10 – The Fat Duck Kitchen Staff Hierarchy



Graphic 7 – The Fat Duck kitchen staff hierarchy.

Appendix 11 – *Sound of the Sea* Dish Simpler Version

Sound of the Sea simpler version

Ingredients:

- **Sand**: Oil, seaweeds, miso, panko, cod liver oil and maltodextrin.
- **Sea**: Seaweed broth and lecithin.
- **Seaweeds**: Ice lettuce, sapphire, tosaka and codium.
- **Ponzu**: Sake, yuzu juice, katsuo bushi and kombu.
- **Fish**: Yellow tail, sugar, bergamot zest, grapefruit zest and lemon zest.

Appendix 12 – Study Proposal

ESCOLA SUPERIOR DE HOTELARIA E TURISMO DO ESTORIL

MESTRADO em INOVAÇÃO EM ARTES CULINÁRIAS

ESPECIALIZAÇÃO: MESTRE

PROPOSTA de: DISSERTAÇÃO - RELATÓRIO de ESTÁGIO

Nome: FILIPE MANUEL DA COSTA LEONOR

Edição do Mestrado: 2012/2014

Tema: Efeito da nostalgia transmitida através do som da iguaria *Sound of the Sea*, na percepção final do gosto.

SÍNTESE da PROPOSTA DE TRABALHO

A Gastronomia faz parte do dia-a-dia de cada um e está mais ligada aos costumes e cultura do ser humano do que na maioria das vezes se possa aperceber. Embora o quotidiano agitado característico que encurta o tempo para a refeição, a gastronomia vai para além de uma mera necessidade fisiológica (MyHealthNewsDaily, 2012).

A Fisiologia do Gosto diz respeito à percepção que temos dos alimentos, está intimamente relacionada com os sentidos que despertam assim como o impacto bioquímico e emocional que têm em nós (Blumenthal, 2008), os cinco sentidos têm um impacto directo na percepção do gosto, no entanto, existem outros factores menos óbvios que podem ser tão ou mais influentes que os primeiros. A nostalgia, sentimento de familiaridade ou lembrança, é um dos factores indirectos que nos afecta subconscientemente e tem grande impacto na percepção final que temos de uma iguaria, esta pode ser a chave que permitirá controlar a satisfação por uma refeição (Shepherd, 2012).

O estudo pretende verificar se a alteração do factor nostalgia transmitida através do som, levará a uma percepção final do gosto diferente. Será analisada a iguaria *Sound of the Sea* por Heston Blumenthal do restaurante The Fat Duck.

OBJECTIVOS

Objectivo geral:

Estudar a influência da nostalgia transmitida através do som da iguaria *Sound of the Sea*, na percepção final do gosto.

Objectivos específicos:

1/4

ESCOLA SUPERIOR DE HOTELARIA E TURISMO DO ESTORIL

Rever e sumariar a bibliografia sobre a problemática de investigação.
Elaborar uma análise sensorial tendo em conta a receita base *Sound of the Sea*, painel de provadores e o factor nostalgia transmitida através do som.
Apurar e analisar os resultados obtidos na análise sensorial.
Desenvolver um modelo de análise que permita definir parâmetros de controlo da percepção final do gosto, através da nostalgia transmitida pelo som.

METODOLOGIA – MÉTODOS e TÉCNICAS a UTILIZAR

A pergunta de partida que permitiu fundamentar o estudo foi *Terá a nostalgia transmitida através do som da iguaria Sound of the Sea, influência na percepção final do gosto?* Pergunta que obrigou à pesquisa e selecção bibliográfica com o principal objectivo de entender de que modo é processado o gosto e quais as áreas de influência na sua percepção final. Para tal foram analisadas as vertentes Gastronómica, Tecnológica e Fisiologia do Gosto.

Na vertente Gastronómica serão analisadas as tendências gastronómicas da actualidade de modo a enquadrar o conceito do restaurante que conceptualizou a iguaria em análise.

Na vertente Tecnológica serão referidas e explicadas as técnicas de confecção e produtos utilizados na iguaria.

Na vertente Fisiologia do Gosto serão estudados os processos referentes à percepção do gosto e as áreas de influência, com especificidade na nostalgia transmitida através do som.

Seguindo a base esquemática metodológica proposta por Quivy (1992), após colocada a pergunta de partida será tratada a fase de leitura que permitirá um entendimento geral do tema a abordar, no entanto para resposta a temas mais específicos será necessário recorrer a um profissional especialista e a um professor doutorado da área que consolidarão e uniformizarão o fio condutor obtido na pergunta de partida. Será posteriormente elaborado um esquema guião do trabalho com limites para execução de tarefas que será menos claro não fosse a realização das entrevistas.

Após a realização das entrevistas exploratórias e um domínio mais profundo das matérias será possível começar a criar as bases para investigação assim como a problemática relacionada com a pergunta de partida.

Na construção do modelo de análise definir-se-ão os indicativos e estímulos a utilizar que permitirão a uma correcta posterior observação.

A fase de observação, parte em investigação em laboratório decorrida em estágio no restaurante The Fat Duck, parte por painel de provadores permitirá a recolha de dados que

ESCOLA SUPERIOR DE HOTELARIA E TURISMO DO ESTORIL

serão posteriormente utilizados para a justificação de bibliografia como para interpretação da pergunta de partida, serão corrigidos erros de análise sensorial.

A análise de informação consistirá no tratamento dos dados obtidos, de modo a que sejam claros os resultados, esta etapa permitirá responder à pergunta de partida.

Por último será feita uma síntese do fio condutor traçado de início e o paralelismo deste com os resultados obtidos que permitirão a resposta à pergunta de partida *Terá a nostalgia transmitida através do som da iguaria Sound of the Sea, influência na percepção final do gosto?*

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CRONOGRAMA

	REVISÃO BIBLIOGRÁFICA	RECOLHA DE DADOS	TRABALHOS PRÁTICOS	ESCRITA E ENTREGA DO TRABALHO
OUTUBRO	X			
NOVEMBRO	X			
DEZEMBRO	X			
JANEIRO	X	X		
FEVEREIRO	X	X		
MARÇO		X	X	
ABRIL		X	X	
MAIO	X			X
JUNHO	X			X
JULHO				X
AGOSTO				X
SETEMBRO				X
OUTUBRO				X

LOCAL de REALIZAÇÃO do TRABALHO

A confecção da iguaria base assim como as provas com painel de provadores serão efectuados no local de estágio, restaurante The Fat Duck, Londres, Reino Unido.

NOTAS/OBSERVAÇÕES

Estabeleceu-se previamente um protocolo de estágio entre a ESHTE e a unidade acima referida, com vista à realização de um estágio conducente à elaboração da tese de mestrado.

4/4

Appendix 13 - Inquiry

Answer the following questions with a 1 to 5 scale, being 1 the lowest grade and 5 the highest.

1 – How salty is the dish? (1-not salty at all; 5-very salty)

☐1 ☐2 ☐3 ☐4 ☐5

2 – How fresh is the dish? (1-not fresh at all; 5-very fresh)

☐1 ☐2 ☐3 ☐4 ☐5

3 – How tasty is the dish? (1-not tasty at all; 5-very tasty)

☐1 ☐2 ☐3 ☐4 ☐5

4 – Does the dish remind you of something familiar? (if you answer Does not remind me, move forward to question 5)

☐Does not remind me ☐Reminds me

4.1 – What was it that felt familiar?

☐Not so good times spent on the sea side ☐Good times spent on the sea side

5 – How much did you enjoy the dish? (1-did not enjoyed at all; 5-enjoyed very much)

☐1 ☐2 ☐3 ☐4 ☐5

Appendix 14 – Internship Journal

The following is a daily journal regarding the internship at the FDEK, it features most procedures and new things I've learnt. Due to the Company's privacy politics, neither photographs or any recipe formula belonging to the Fat Duck are allowed to be published.

The Fat Duck Experimental Pastry Kitchen

Day 1 – TV show and development of Afternoon Earl Grey tea jelly
Date: 08-01-2014 Wednesday **Working Time:** 8h-19h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food* and finish development of *Afternoon Earl Grey tea jelly*.

Main Tasks: Tv Show -Earl Grey Tea Shiffon, Base Shiffon. Development – Adjust jelly texture in order to achieve a cold honey like texture.

Procedures and Results:

Recipe	Result
Earl Grey tea jelly A	• Sweetness already achieved; • Low acidity • Fluid gel texture (no good)
Earl Grey tea jelly B	• Fluid gel texture (no good)
Earl Grey tea jelly C	• Fluid gel texture (no good)
Earl Grey tea jelly D	• Fluid gel texture, almost liquid (no good)

Learning

- High-methyl Pectin Jaune (yellow pectin 73%) sets better in acidic and high sugar content solutions than Low-Methyl Pectin NH Nappage (26-33%) (see Appendix 5)
- Fructose enhances fruit flavor (see Appendix 5)
- Citric acid enhances citric fruit acidity (see Appendix 5)

Day 2 – TV show and development of Afternoon Earl Grey tea jelly
Date: 09-01-2014 Thursday **Working Time:** 8h-21h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food* and finish development of *Afternoon Earl Grey tea jelly*.

Main Tasks: Tv Show **-**Earl Grey Tea Shiffon, Base Shiffon, Sweet smoked salmon, Sweet sliced ham. Development – Adjust jelly texture in order to achieve a cold honey like texture.

Procedures and Results:

Recipe	Result
Earl Grey tea jelly E	• Thick texture, almost like jam (no good)

Learning

- For Sweet smoked salmon texture a combination of Gellan F+LT100 (see Appendix 5) was used, Gellan F (low-acyl) sets hard and has heat resistance properties so once set it becomes brittle doesn´t melt with temperature, LT100 (high-acyl from Gellan family) sets with more elasticity. Combination results in texture similar to fish.

Day 3 – TV show and development of Afternoon Earl Grey tea jelly
Date: 10-01-2014 Friday **Working Time:** 8h-23h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food* and finish development of *Afternoon Earl Grey tea jelly*.

Main Tasks: Tv Show **-**Earl Grey Tea Shiffon, Base Shiffon, Sweet sliced cheese, Earl Grey Tea ganache, Chocolate works. Development – Adjust jelly texture in order to achieve a cold honey like texture.

Procedures and Results:

Recipe	Result
Earl Grey tea jelly F (has apple instead of pectin)	• Cold honey texture achieved (but a bit harder than the one wanted) • Flavor excessively altered (but good result) • Acidity achieved
Earl Grey tea jelly G (has apple instead of pectin)	• Cold honey texture achieved • Flavor altered (good result) • Acidity achieved

Learning

- Fruit natural pectin achieved from apple and lemon juice seems to have easier results on the texture wanted.

Day 4 – TV show
Date: 11-01-2014 Saturday **Working Time:** 9h-21h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*.

Main Tasks: Tv Show -Chocolate works.

Procedures and Results: No development

Learning

Day 5 – TV Show and development of Hot Chocolate BFG
Date: 13-01-2014 Monday **Working Time:** 8h-19h30m

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*. Development of *Hot Chocolate BFG* for Switzerland event.

Main Tasks: Tv Show -Chocolate works, sweet smoked salmon, cucumber mace. Development – Hot Chocolate BFG.

Procedures and Results:

Recipe	Result
BFG – Hot chocolate BASE	• Strong drink, sort of bitter taste • Missing something, doesn't taste like BFG

Learning

- Nothing relevant

Day 6 – TV Show
Date: 14-01-2014 Tuesday **Working Time:** 8h-20h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*.

Main Tasks: Tv Show -Chocolate works

Procedures and Results:

Learning

- Nothing relevant

Day 7 – Preparation House – White Chocolate Room
Date: 15-01-2014 Wednesday **Working Time:** 7h-23h

Objectives: Produce mise-en-place for The Fat Duck main kitchen

Main Tasks: Queen of Hearts cards, whiskey gums, commis chef related tasks

Procedures and Results:

Learning

- Freeze dryer (see Appendix 3) is used for the *Botrytis Cinerea* dish, to concentrate apricot flavor.
- I've had the opportunity to use a pH meter to measure the cherry coulis acidity for the Black *Forest Gateaux*, it allows control the same acidic sensation every time (see Appendix 3).

Day 8 – Preparation House – Dark Chocolate Room
Date: 16-01-2014 Thursday **Working Time:** 7h-21h

Objectives: Produce mise-en-place for The Fat Duck main kitchen

Main Tasks: Aerated chocolate for bonbon and BFG, popping candy bonbon, commis chef related tasks

Procedures and Results:

Learning

- While preparing the *Mandarin Aerated Chocolate Bonbons* I had the chance to learn how to operate a vacuum oven (see Appendix 3).
- Chocolate e tempered before used, the tempering technique is not complicated however the room conditions must be carefully set (see Appendix 6).

Day 9 – TV Show
Date: 17-01-2014 Friday **Working Time:** 8h-19h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*.

Main Tasks: Tv Show -Chocolate works

Procedures and Results:

Learning

- Nothing relevant

Day 10 – TV Show
Date: 20-01-2014 Monday **Working Time:** 8h-19h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*.

Main Tasks: Tv Show -Chocolate works

Procedures and Results:

Learning

- Nothing relevant

Day 11 – TV Show and Development of Desert for The Crown
Date: 21-01-2014 Tuesday **Working Time:** 8h-20h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*. Development of new desert for The Crown pub

Main Tasks: Tv Show **-**Chocolate works. Development – Highlights for next day: start thinking of way to do lemon tart that goes with the concept of a pub.

Procedures and Results:

Learning

- Nothing relevant

Day 12 –Development of Desert for The Crown and After Eight paste **base**
Date: 22-01-2014 Wednesday **Working Time:** 8h-18h

Objectives: Development of new desert for The Crown pub and base for After Eight paste.

Main Tasks: Development – After Eight paste and lemon tart components: Lemon Preserve, Lynzer-type Shortbread and Swiss-meringue.

Procedures and Results:

Recipe	Result
After Eight Paste A	• Too liquid, • Flavor not ideal
After Eight Paste B	• Too liquid, • Flavor not ideal
After Eight Paste C	• Too solid, • Flavor not ideal
Lemon Preserve	• Too thin, • It was supposed to have a jam like texture
Lynzer-type Shortbread (without yolk)	• Good texture and flavor, • Waiting for comparison with recipe containing yolk
Lime Swiss-Meringue	• Good texture and flavor • Not stable

Learning

Day 12 –TV Show and Development of Desert for The Crown and After Eight paste base
Date: 23-01-2014 Thursday **Working Time:** 8h-20h

Objectives: Produce mise-en-place for the upcoming TV show *Heston's Great British Food*. Development of base for After Eight paste.

Main Tasks: TV Show – Chocolate works **-** Development – After Eight paste.

Procedures and Results:

Recipe	Result
After Eight Paste D	• Too grainy • Flavor not ideal
After Eight Paste E	• Too grainy • Ideal Flavour
After Eight Paste F	• Too grainy • Ideal Flavour
After Eight Paste G	• Too grainy • Ideal Flavour

Learning

- New challenge: try to recreate the making of a real after eight (in giant form) using Ivertase, it's an enzyme that converts sugar (crystal form) into inverted sugar, same process as bees making honey (see Appendix 5).

Day 13 –Development of Desert for The Crown
Date: 24-01-2014 Friday **Working Time:** 8h-16h

Objectives: Development of new desert for The Crown.

Main Tasks: Development – Lynzer-type Shortbread.

Procedures and Results:

Recipe	Result
Lynzer-type Shortbread (with yolk)	• Texture and flavor similar to previous one, because it takes more time to make, it will be discarded

Learning

- Nothing relevant

Day 14 –Development of Desert for The Crown
Date: 27-01-2014 Monday **Working Time:** 8h-18h

Objectives: Development of new desert for The Crown.

Main Tasks: Development – Citrus curd.

Procedures and Results:

Recipe	Result
Yuzu curd (C.P.) - 1	• Good result, recipe already been developed. • Will be used as base.
Yuzu and Lemon curd (50/50) (C.P.) - 2	• Good result, not so good texture
Yuzu and Lemon curd (30/70) (C.P.) - 3	• Good result, not so good texture • Yuzu flavor is not evident

Learning

- The two last recipes were tested in order to reduce food cost (without changing flavor)
- C.P. – Citrus Pie

Day 15 –Development of Desert for The Crown
Date: 28-01-2014 Tuesday **Working Time:** 8h-19h

Objectives: Development of new desert for The Crown.

Main Tasks: Development – Citrus curd.

Procedures and Results:

Recipe	Result
Citrus Curd - 4 Base recipe 33% juice is Yuzu 33% juice is Lemon 33% juice is Lime	• Flavor not similar to Yuzu • Bad texture
Citrus Curd - 5 Base recipe 25% juice is Yuzu 25% juice is Lemon 25% juice is Lime 25% juice is Pink Grapefruit	• Flavor not similar to Yuzu • Bad texture
Citrus Curd - 6 Base recipe 30% juice is Lemon 10% juice is Lime 60% juice is Pink Grapefruit	• Flavor close to Yuzu • Excellent texture
Citrus Curd – 7 Base recipe 20% juice is Lemon 10% juice is Lime 70% juice is Pink Grapefruit	• Flavor close to Yuzu, but loosing acidity • Texture very good but not as good as curd 6
Citrus Preserve 30% juice and rind is Lemon 10% juice and rind is Lime 60% juice and rind is Pink Grape Fruit More amount of Sugar Fructose	• Good balance with the other components of pie • Less acidity, more bitterness

Learning

- Curd being used is **3**, Shortbread Lynser-type, Swiss-meringue waiting for recipe change in order to achieve longer stability.
- Pie will have shortbread, citrus preserve to balance acidity and sweetness, citrus curd, vanilla chantilly (which has volatile compounds of the same family of some of the other components) and meringue.

Day 16 –Production for Event in Switzerland and Development of Desert for The Crown
Date: 29-01-2014 Wednesday **Working Time:** 8h-20h

Objectives: Production for event in Switzerland and Development of new desert for The Crown.

Main Tasks: Development – Lemon Meringue.

Procedures and Results:

Recipe	Result
Lime Swiss-Meringue	• Good texture and flavor • Not stable
Lime Italian-Meringue A	• Good texture and flavor • Not stable
Lime Italian-Meringue B	• Texture too hard (split), good flavor • Not stable

Learning

- Each egg white contains 12,3% albumin, which makes the structure of the foam by denaturation, higher temperature stabilizes the foam longer, acidity helps too.

Day 17 – Production for Event in Switzerland, Development of Desert for The Crown and Kulfi parfait for TV show
Date: 30-01-2014 Thursday **Working Time:** 8h-20h

Objectives: Production for event in Switzerland, Development of new desert for The Crown and structure the best way to produce a large scale size After Eight (Kulfi Parfait)

Main Tasks: Development – Lemon Meringue and design concept for Kulfi

Procedures and Results:

Recipe	Result
Instant Swiss-Meringue	• Good texture (but not perfect) • Ready to use but once out of siphon doesn't last long

Learning

- Albumin, with sugar in the solution coagulates at higher temperature, permitting to stabilize longer the meringue mixture
- The was place for tasting of Soy sauce and Mirin from a private company that came by the restaurant and they were the best ones I've ever tasted, there was an unusual combination that got my attention, Soy sauce and Mirin cooked with cream and butter. The flavor was complex, like a caramel/palm guar/molasses/yeast (full of umami that was easily noticed because of high amount of protein and fat) which is perfect to go as an ice cream garnish for a sour dish.

Day 18 –Development of Desert for The Crown
Date: 31-01-2014 Friday **Working Time:** 8h-17h

Objectives: Development of new desert for The Crown

Main Tasks: Development – Citrus Curd

Procedures and Results:

Recipe	Result
Citrus Curd 3A Base 3 with 2x juice	• Flavor more evident (good result) • Soft texture
Citrus Curd 3B Base 3A + more egg	• Flavor more evident • Good texture
Citrus Curd 3C Base 3B Substitute (X)g sucrose for (Y)g sucrose and (Z)g fructose	• Similar result as 3B
Citrus Curd 3D Base 3B Substitute (A)g sucrose for (B)g fructose	• waiting for tasting
Citrus Curd 8 Base 3B 20% yuzu 40% pink grape fruit 40% lemon	• waiting for tasting • texture tend to soften
Citrus Curd 9 Base 3B 20% yuzu 20% pink grape fruit 60% lemon	• waiting for tasting • texture tend to soften
Citrus Curd 10 Base 3B 20% yuzu 60% pink grape fruit 20% lemon	• waiting for tasting • texture tend to soften
Citrus Curd 11 Base 3B 10% yuzu 30% pink grape fruit 60% lemon	• waiting for tasting • softer texture
Citrus Curd 12 Base 3B 10% yuzu 60% pink grape fruit 30% lemon	• waiting for tasting • softer texture

Citrus Curd 13 Base 3B 10% yuzu 45% pink grape fruit 45% lemon	• waiting for tasting • softer texture

Learning

- Quantity of fructose being used on 3C was calculate according to the following (in order to achieve the same sensation of sweetness as 3B): Sucrose relative sweetness=1; Fructose related sweetness=1,52. For a 40g amount of sucrose in recipe:
    - 100g (total)= 40g x 1 + 1,52X
      X=60/1,52; X=40g Fructose
- Quantity of fructose being used on 3D was calculate according to the following:
    - 100g = 1,52X
      X=100/1,52; X=66g Fructose
- Yuzu juice seems to have an important role on the texture of the curd

Day 19 –Development of Desert for The Crown
Date: 03-02-2014 Monday **Working Time:** 8h-16h

Objectives: Development of new desert for The Crown

Main Tasks: Development – Citrus meringue (stable long enough to be used during service for 3h)

Procedures and Results:

Recipe	Result
Meringue A (Italian)	• Good texture at beginning, after 30min tends to split and agglomerate • Lasts +3h
Meringue B (French)	• Good texture • Lasts 30min
Meringue C (French)	• Seems saturated (sugar didn´t dissolve • No good
Meringue C1 (French)	• Dense texture, tends to get liquid after 40min • Lasts +3h
Meringue D (French)	• Light texture, tends to split after 30min • Lasts +3h
Meringue E (Swiss)	• Light texture, looks fresh • After 40min tends to split • Lasts +3h
Meringue F (Swiss)	• Dense texture, looks fresh and glossy • After 30min tends to get liquid • Lasts +3h
Meringue G (Swiss) (60ºC after charging siphon)	• Good texture, looks very fresh • Lasts +/- 1min
Meringue G1 (Swiss) Same as G but on 65ºC after charging siphon	• Good texture, looks very fresh • Lasts +/- 1min
Meringue G2 (Swiss) Same as G but on 70ºC after charging siphon	• Good texture, looks very fresh • Lasts +/- 1min

Meringue H (Swiss) (60ºC after charging siphon)	• Good texture, looks very fresh • Lasts +/- 1min
Meringue H1 (Swiss) Same as H but on 65ºC after charging siphon	• Good texture, looks very fresh • Lasts +/- 1min
Meringue H2 (Swiss) Same as H but on 70ºC after charging siphon	• Good texture, looks very fresh • Lasts +/- 1min
Meringue I (French)	• Good texture, looks glossy, easy to work • After 20min tends to split
Meringue J (Swiss) (icing sugar and acid added on whipping stage)	• Good texture, looks very fresh and glossy, easy to work • Looks fresh even after 2h but starts to lump a little (but texture remains really good)
Meringue K (Swiss) (icing sugar and acid added before cooking)	• Good texture, looks very fresh, glossy and smooth, easy to work • Looks fresh even after 2h

Learning

- Acid, sugar, temperature and corn starch are ingredients that stabilize the foam, H+ react with the proteins, temperature used denatures them (not completely), sugar added in the beginning permits smaller bubbles (denser foam and more stable) and corn starch absorbs moisture and helps the foam to not lose water.
- Cooked corn starch seems to help better with the structure of the meringue, the K result was smoother than J.

Day 20 –Development of Kulfi for TV Show
Date: 04-02-2014 Tuesday **Working Time:** 8h-19h

Objectives: Development of after eight looking parfait for TV show

Main Tasks: Development – Kulfi base.

Procedures and Results:

Recipe	Result
Kulfi base	• Good texture flavour not there

Learning

- Nothing relevant

Day 21 –Development of Kulfi for TV Show and Dessert for The Crown
Date: 05-02-2014 Wednesday **Working Time:** 8h-19.30h

Objectives: Development of after eight looking parfait for TV show, citrus curd and meringue.

Main Tasks: Development – Kulfi base, citrus crud and meringue

Procedures and Results:

Recipe	Result
Kulfi base	• Good texture, flavour not there
Citrus curd 3E (from base 3A 30%yuzu-70%lemon)	• Good texture, not very different from 3A
Citrus curd 3	• Good texture, flavor is less evident than 3A
Citrus curd 3G	• Very good texture, flavor evident bur less than 3A
Citrus curd 3H	• Good texture, flavor really similar to 3A
Meringue L	• Great texture, very easy to work. • Very stable
Meringue M	• Great texture but denser than previous, easy to work. • Very stable

Learning

- Nothing relevant

Day 22 -Kulfi for TV Show
Date: 06-02-2014 Thursday **Working Time:** 8h-20h

Objectives: Kulfi production for Tv Show

Main Tasks: TV Show – Kulfi base.

Procedures and Results:

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Learning

- For quickly freezing the base into a square a metal mold was used and put on the deep freezer (Polar bear) for almost instant freezing (see Appendix 3).

Day 23 -Kulfi for TV Show
Date: 07-02-2014 Friday **Working Time:** 8h-19h

Objectives: Kulfi production for Tv Show

Main Tasks: TV Show – Kulfi base.

Procedures and Results:

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Learning

- Nothing relevant

Day 24 -Kulfi for TV Show
Date: 10-02-2014 Monday **Working Time:** 8h-19h

Objectives: Kulfi production for Tv Show

Main Tasks: TV Show – Kulfi base and dipping in chocolate

Procedures and Results:

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Learning

- Nothing relevant

Day 25 –Development of savory Mars Bar
Date: 10-02-2014 Tuesday **Working Time:** 8h-19h

Objectives: Develop of sour mars bar

Main Tasks: Development: -salty beef caramel and aerated chocolate Guinness

Procedures and Results:

Recipe	Result
Salty caramel A	• Liquid (not good)
Salty caramel B	• Good texture; • Flavor not close
Salty caramel C	• Good texture; • Flavor not close

Learning

- Nothing relevant

Day 26 –Development of savory Mars Bar
Date: 12-02-2014 Wednesday **Working Time:** 8h-20h

Objectives: Develop of sour mars bar

Main Tasks: Development: -salty beef caramel and aerated chocolate Guinness

Procedures and Results:

Recipe	Result
Salty caramel D	• Good texture • Flavor close
Salty caramel E	• Good texture; • Pretended flavor
Salty caramel F	• Hard texture • Flavor not perfect

Learning

- Nothing relevant

Day 27 –Development of side for Rhubarb dish
Date: 13-02-2014 Thursday **Working Time:** 8h-19h

Objectives: Develop Lemon Bam side for *Rhubarb* dish

Main Tasks: Development: - Lemon Bam emulsion, Lemon Bam fluid gel

Procedures and Results:

Recipe	Result
Lemon Bam Emulsion	• Very good emulsion • Not very tasty
Lemon Bam Fluid gel A	• Too thick • Good flavor release • Loses green after a while
Lemon Bam Fluid Gel B	• Good texture • Good flavor release • Loses green after a while

Learning

- Process of making lemon Bam oil consists in blanching the leaves, cover in oil, freeze and paco-jet it. Leaving over-night in cloth to separate the oil, color and flavor only.
- Fluid gel is a liquid gel that is stable when left on a surface but deforms when a force is applied (see Appendix 6)

Day 28 –Development of side for Rhubarb dish
Date: 14-02-2014 Friday **Working Time:** 8h-18h

Objectives: Develop Lemon Bam side for *Rhubarb* dish

Main Tasks: Development: -Lemon Bam fluid gel, Lemon Bam essential oil.

Procedures and Results:

Recipe	Result
Lemon Bam Fluid gel C	• Doesn't emulsify
Lemon Bam Essential oil thickened	• Waiting for tasting

Learning

- Glice obtained from fatty acids consist in mono and diglycerides that once broken down (by temperature) blend with fat and permit emulsion when added to water component.
- Lemon Bam fluid gel was discarded, the restaurant wants to use the clear oil but thickened
- New idea: Chocolate Ginjinha, ginjinha infused with chocolate, then clarified in the centrifuge (see appendix 3) to separate the solids but retain the volatile on top. The result is a ginjinha in a cup of chocolate flavor but with no cup of chocolate.

Day 29 –Production for TV Show
Date: 17-02-2014 Monday **Working Time:** 8h-17h

Objectives: Production for Tv Show

Main Tasks: TV Show – BFG hot drink, savory mars bar, medicinal historic chocolate drink

Procedures and Results:

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Learning

- Nothing relevant

Day 30 –Development of side for Rhubarb dish
Date: 18-02-2014 Tuesday **Working Time:** 8h-18h

Objectives: Development of side for *Rhubarb* dish

Main Tasks: Development – Lemon Bam Fuelletine

Procedures and Results:

Recipe	Result
Lemon Bam Fuelletine	• Good result

Learning

- Nothing relevant

Day 31 –Development of side for Rhubarb dish and Starting of research for Masters Final Report
Date: 19-02-2014 Wednesday **Working Time:** 8h-18h

Objectives: Development of side for *Rhubarb* dish

Main Tasks: Development – Lemon oil and candied ginger

Procedures and Results:

Recipe	Result
Candied Ginger	• Good result
Lemon Bam Essential oil thickened	• Perfect texture

Learning

- It was discussed with Head Chef what would be made for masters final report, the idea is to investigate what roll nostalgia triggered by sound can have. For that the Sounds of the Sea dish will be studied, the sound of the sea side will bring memories for some of the tasters, will it have any significant difference in the final perception of the dish?

Day 32 –Production for TV Show
Date: 20-02-2014 Thursday **Working Time:** 8h-23h

Objectives: Production for the Chocolate episode of *Heston's Great British Food*

Main Tasks: Assistant related functions

Procedures and Results:

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Learning

- Nothing relevant

Day 33 –Production for TV Show
Date: 21-02-2014 Friday **Working Time:** 8h-23h

Objectives: Production for the Chocolate episode of *Heston's Great British Food*

Main Tasks: Assistant related functions

Procedures and Results:

--

Learning

- Nothing relevant

The Fat Duck Experimental Kitchen

Day 34 – Production for TV Show
Date: 24-02-2014 Monday **Working Time:** 8h-19h

Objectives: Adapt to new working methods in the new Lab

Main Tasks: Assistant related tasks

Procedures and Results:

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Learning

- There is a specific job every Monday given to the stagier, to do MEP of the oak strips for the quail dish. It is a complex recipe and hard to make since measurements are extremely precise. A precision laboratory scale is needed (see Appendix 3) as well as an over-head stirrer to allow emulsion of small quantities without incorporating air (see Appendix 3). When the recipe is done, it sets 24h and is spread into glass trays with a very precise film applicator (see Appendix 3) and let dry for 3 days depending whether conditions.
- Because it is such a sensible recipe and easy to get it wrong, in order to not have any undesired reactions, deionized water has to be used (see Appendix 6).

Day 35 –Development for Waitrose
Date: 25-02-2014 Tuesday **Working Time:** 8h-19h

Objectives: Enhance coriander biscuit flavor, adjust texture of raspberry cake and test tiramisu recipe

Main Tasks: Assistant related tasks

Procedures and Results:

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Learning

- Nothing relevant

Day 36 –Development for Waitrose
Date: 26-02-2014 Wednesday **Working Time:** 8h-19.30h

Objectives: Enhance coriander biscuit flavor, get ribs smoked and not steamed, create a tasty tagarashi mix for dried fruits

Main Tasks: Assistant related tasks

Procedures and Results:

Ingredients	A	B	C	D
Tagarashi Mix	• Different ratios • Same ingredients			

Learning

- The pork ribs were cured in a brine until it reached equilibrium and the slow cooked sous-vide (see Appendix 6) for 72h at 60ºC. The result was the most tender and juicy meat I've ever tasted.

Day 37 –Development for Waitrose
Date: 27-02-2014 Thursday **Working Time:** 8h-19h

Objectives: Get ribs smoked and not steamed, enhance tagarashi mix taste for dried fruits

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Procedure
Smoked Ribs	

Ingredients	E	F	G	H (chosen)
Tagarashi Mix	• Different ratios • Same ingredients			

Learning

Day 36 –Development of jelly beans for the Fat Duck
Date: 28-02-2014 Friday **Working Time:** 8h-19h

Objectives: Make a jelly bean base to test with different flavors to go in the sweet shop basket at the end of the menu.

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Procedure
Base For Jelly beans	

Learning

- To control the sugar content in the jelly beans base, a refractometer was used. It scales in brix the sugar content in solutions (see Appendix 3).

Day 37 –MEP for Tasting
Date: 03-03-2014 Monday **Working Time:** 8h-17h

Objectives: Make mise-en-place for tasting the next day

Main Tasks: Assistant related tasks

Procedures and Results:

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Learning

- Although I am not any more at the pastry lab, the other stagier came to the main lab sharing his new project, which was to develop ready to churn ice cream recipes for the new terminal two Heston Blumenthal restaurant. He was having some problems in the development (texture wise) due to the limitations of the new restaurant. Therefore I went studying deeper than I had learned in the master's degree about the science of ice cream making (see Appendix 6) and ended up developing an excel sheet ready to create stable and well balanced ice cream recipes (also see Appendix 6).

Day 38 –MEP for Tasting
Date: 04-03-2014 Tuesday **Working Time:** 8h-20h

Objectives: Make mise-en-place for tasting.

Main Tasks: Assistant related tasks

Procedures and Results:

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Learning

- Nothing relevant

Day 39 –Development of jelly beans for The Fat Duck
Date: 05-03-2014 Wednesday **Working Time:** 8h-21h

Objectives: Have 6 different flavors by the end of the day

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Rhubarb Rhubarb juice Base	• Final brix 68 • Flavor not evident • Texture very chewy
Carrot Carrot juice Base	• Final brix 66 • Good Flavor • Texture very chewy
Buck Thorn Buck Thorn juice Base	• Final brix 63 • Flavor sort of cheesy in the end • Texture chewy but close to the one wanted
Pedro Ximénez Pedro Ximénez Base	• Final brix 61 • Very nice flavor • Perfect texture
Red Pepper Red pepper juice Base	• Final brix 64 • Interesting flavor • Texture very chewy
Malt malt solution Base	• Final brix 74 • Nice flavor • Texture extremely chewy

Learning

- Juices are reduced in the rocket until they reach the desired sugar%. Rocket evaporator is a very sensitive distiller, used to concentrate solutions losing very few volatile compounds (see Appendix 3)
- Jelly is dehydrated in corn flour

Day 40 –MEP for Filming for TV Show
Date: 06-03-2014 Thursday **Working Time:** 5h-21h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

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Learning

- Helping to develop chocolate beer for the upcoming show, chocolate solution has distilled in the rotary evaporator. The rotary evaporator is a distiller device, used to concentrate solutions, in one side water with volatile compounds and the other the concentrated solution with the remaining volatile compounds (see Appendix 3).

Day 41 –Filming for TV Show
Date: 07-03-2014 Friday **Working Time:** 8h-18h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

--

Learning

Day 41 –Development of jelly beans for The Fat Duck
Date: 10-03-2014 Monday **Working Time:** 8h-18h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Rhubarb Rhubarb juice Base	• Final brix 61 • Good flavor • Perfect texture
Carrot Carrot juice Base	• Final brix 61 • Good Flavor • Perfect texture
Buck Thorn Buck Thorn juice Base	• Final brix 61 • Flavor sort of cheesy in the end • Perfect texture
Pedro Ximénez Pedro Ximénez Base	• Final brix 61 • Very nice flavor • Perfect texture
Red Pepper Red pepper juice Base	• Final brix 61 • Interesting flavor • Perfect texture
Malt malt solution Base	• Final brix 61 • Nice flavor • Texture a little chewy

Learning

- Malt seems to have effect on texture of jelly bean once is dehydrated

Day 41 –Development of jelly beans for The Fat Duck
Date: 11-03-2014 Tuesday **Working Time:** 8h-19h

Objectives: Trial on soft panning

Main Tasks: Assistant related tasks

Procedures and Results:

--

Learning

- The assistant development chef was working on a new dish for the Fat Duck and it had a clarified stock in its recipe. Traditional clarification lets most of the valuable volatile molecules evaporate with the steam, however he used a technique called ice filtration which has many benefits for some applications (see Appendix 6).

Day 42 –Development of jelly beans for The Fat Duck
Date: 12-03-2014 Wednesday **Working Time:** 8h-18h

Objectives: trial on soft panning

Main Tasks: Assistant related tasks

Procedures and Results:

--

Learning

- Meeting with Head Chef discussing what would be needed for the sensory tasting.
- I started noticing how much pressure cookers are used at the laboratory, we have 8 of them just in the lab. After some questioning and research again in my master's degree paper works I reminded how beneficial its use can be for certain recipes (see Appendix 3).

Day 43 –Development of jelly beans for The Fat Duck and Corn dip for Waitrose
Date: 13-03-2014 Thursday **Working Time:** 8h-18h

Objectives: trial on soft panning

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Corn dip Base Sweet corn juice, cooked until thicken	• Very sweet thick dip
A	• Nice flavor but too heavy
B (has coffee)	• Interesting flavor
C	• Very interesting flavor
D (has coffee)	• Same as B

Learning

- The use of coffee is not by chance, I was given access to a database called Food Paring, it allows crossing different volatile compounds and find out which ingredients may have similar volatile profile and go well together (see Appendix 3).

Day 44 –Development of jelly beans for The Fat Duck, avocado burger sauce and British kebab for Waitrose

Date: 14-03-2014 Friday **Working Time:** 8h-18h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Vanilla Rhubarb Rhubarb juice vanilla pod (scraped) Base	• Final brix 61 • Really good flavor • Perfect texture
Beer-Malt Beer-Malt solution base	• Final brix 61 • Interesting flavor • Perfect texture

Recipe	Result
Avocado sauce	• Very nice smoky flavor • Has some acidity which is a good result

Learning

- Nothing relevant

Day 45 –Development of jelly beans for The Fat Duck and British Kebab for Waitrose
Date: 17-03-2014 Monday **Working Time:** 8h-18h

Objectives: soft panning technique

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe		
Kebab A	**Kebab B**	**Kebab C** (chosen)

Learning

- Nothing relevant

Day 46 –Development of jelly beans for The Fat Duck and pork pie filling for waitrose
Date: 18-03-2014 Tuesday **Working Time:** 8h-19.30h

Objectives: soft panning technique

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Pork Pie Filling	• Good flavor • Is missing texture, try to add bacon pieces, lard dices and more diced meat?

Learning

- Nothing relevant

Day 47 –Development of jelly beans for The Fat Duck and kebab garnish for waitrose
Date: 19-03-2014 Wednesday **Working Time:** 8h-19.30h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Custard drops of custard flavor Base	• Final brix 61 • Nice flavor • Perfect texture

Recipe	Result
Pickled veggies	• Really nice flavor
Red pepper sauce	• Really good result

Learning

- Nothing relevant

Day 48 –Development of jelly beans for The Fat Duck and Pork pie for Waitrose
Date: 20-03-2014 Thursday **Working Time:** 8h-18h

Objectives: Assistant related tasks

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Pork Pie Dough	• Good texture dough

Learning

- Try adding more fat into the dough? It becomes liquid and very hard to work with.
- Since we cannot do it directly at the beginning of the kneeling, why not try adding all the fat slowly during kneeling (as making a mayo)?

Day 49 –Development of jelly beans for The Fat Duck
Date: 21-03-2014 Friday **Working Time:** 8h-18h

Objectives: Soft panning technique

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Nothing relevant

Day 50 –Development of jelly beans for The Fat duck
Date: 24-03-2014 Monday **Working Time:** 8h-18h

Objectives: MEP

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- I had to do staff meal, and there was not much to do for development, so as garnish I made triple cooked chips. To find the perfect potatoes, a dry matter scale was used to know how much (on average) of dry matter each batch of potato had (see Appendix 3).

Day 51 –Development of jelly beans for The Fat duck and Lamb Burger for Waitrose
Date: 25-03-2014 Tuesday **Working Time:** 8h-18.30h

Objectives: Have two versions of lamb burger

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Cucumber based	• Really good result (fresh)
Tomato-onion based	• Really good result (complex)

Learning

- Nothing relevant

Day 52 –Development of jelly beans for The Fat duck, tandoori style chicken sandwich and grilled thickle style chicken sandwich
Date: 26-03-2014 Wednesday **Working Time:** 8h-18h

Objectives: Have two different chicken sandwiches

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Nothing relevant

Day 53 –Development of jelly beans for The Fat duck, Avocado and quinoa grilled chicken for waitrose

Date: 27-03-2014 Thrusday **Working Time:** 8h-18h

Objectives: Have two different chicken salads

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Salad A	• Very good (chosen)
Salad B	• Good result

Day 54 –Development of jelly beans for The Fat duck, Avocado and quinoa grilled chicken for waitrose
Date: 28-03-2014 Friday **Working Time:** 8h-18h

Objectives: Adjust recipes from day before

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Nothing relevant

Day 55 –Development of jelly beans for The Fat duck, Pork pie dough for Crown
Date: 31-03-2014 Monday **Working Time:** 8h-18h

Objectives: have a way to add fat in pork Pie dough

Main Tasks: Assistant related tasks

Procedures and Results:

Recipe	Result
Pork Pie Dough B	• Really nice texture dough • Added in the beginning
Pork Pie Dough C	• Really nice texture dough • Hard to work with • Added in the beginning
Pork Pie Dough D	• Really nice texture dough • Added while kneeling
Pork Pie Dough E	• Great texture dough • Starting to get hard to work • Added while kneeling
Pork Pie Dough F	• Great texture dough • Hard to work with • Added while kneeling

Learning

- It seems that not only the reaction between ingredients affect the final result, mechanical processes may hold the key to go to the next level when working on the edge.
- The kneeling process creates gluten, gluten is elastic and is formed by starch, it expands and absorbs when hot (as in the beginning of the recipe) and then trap whatever is absorbed (in this case fat) while getting cold.
- Meeting with head chef for next day’s tasting

Day 56 –Pass all information to the new stagier
Date: 01-04-2014 Tuesday **Working Time:** 8h-18h

Objectives: Have the tasting for personal study

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Tasting for dissertation study assay

Day 57 –Pass all information to the new stagier
Date: 02-04-2014 Wednesday **Working Time:** 8h-18h

Objectives: Pass information so the development may go on

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Nothing relevant

Day 58 –Pass all information to the new stagier
Date: 03-04-2014 Thursday **Working Time:** 8h-18h

Objectives: Pass information so the development may go on

Main Tasks: Assistant related tasks

Procedures and Results:

Learning

- Nothing relevant

Day 59 –Observation at the Service Kitchen
Date: 04-04-2014 Friday **Working Time:** 8h-18h

Objectives: Observation day: Take the most out of the experience

Main Tasks: Assistant related tasks and taste the Fat Duck Menu

Procedures and Results:

Learning

- Nothing relevant

Appendix 15 – Performance Evaluation

25th June 2014

To Whom It May Concern:

This letter confirms that Filipe Leonor completed a stage placement in The Fat Duck Experimental Kitchen from 8th January – 4th April 2014.

In the time that Filipe spent with us he contributed to many different development projects; these included dishes for both The Fat Duck and The Crown. Filipe was also involved in TV work and he assisted with development on several different episodes of 'Heston's Fantastical Food.' In addition, Filipe took part in commercial development as part of The Fat Duck's relationship with Waitrose supermarket.

Filipe's good attitude and methodical approach mean that he is well suited to development. I would like to thank Filipe for his dedication, interest and the high standard of his work.

On behalf of all at The Fat Duck Experimental Kitchen, I would like to wish him all the best in his future career.

Yours sincerely

Jonny Lake
Head Chef

The Fat Duck
heston blumenthal

Appendix 16 – Study Results

With Sound Influence

Answer the following questions with a 1 to 5 scale, being 1 the lowest grade and 5 the highest.

1 – How salty is the dish? (1-not salty at all; 5-very salty)

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2 – How fresh is the dish? (1-not fresh at all; 5-very fresh)

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3 – How tasty is the dish? (1-not tasty at all; 5-very tasty)

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4 – Does the dish remind you of something familiar? (if you answer Does not remind me, move forward to question 5)

☐ Does not remind me ☑ Reminds me

4.1 – What was it that felt familiar?

☐ Not so good times spent on the sea side ☑ Good times spent on the sea side

5 – How much did you enjoy the dish? (1-did not enjoyed at all; 5-enjoyed very much)

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1 – How salty is the dish? (1-not salty at all; 5-very salty)

☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

2 – How fresh is the dish? (1-not fresh at all; 5-very fresh)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☑ 5

3 – How tasty is the dish? (1-not tasty at all; 5-very tasty)

☐ 1 ☐ 2 ☐ 3 ☑ 4 ☐ 5

4 – Does the dish remind you of something familiar? (if you answer Does not remind me, move forward to question 5)

☐ Does not remind me ☑ Reminds me

4.1 – What was it that felt familiar?

☐ Not so good times spent on the sea side ☑ Good times spent on the sea side

5 – How much did you enjoy the dish? (1-did not enjoyed at all; 5-enjoyed very much)

☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5

Answer the following questions with a 1 to 5 scale, being 1 the lowest grade and 5 the highest.

1 – How salty is the dish? (1-not salty at all; 5-very salty)

☐ 1 ☐ 2 ☒ 3 ☐ 4 ☐ 5

2 – How fresh is the dish? (1-not fresh at all; 5-very fresh)

☐ 1 ☐ 2 ☐ 3 ☒ 4 ☐ 5

3 – How tasty is the dish? (1-not tasty at all; 5-very tasty)

☐ 1 ☐ 2 ☐ 3 ☒ 4 ☐ 5

4 – Does the dish remind you of something familiar? (if you answer Does not remind me, move forward to question 5)

☐ Does not remind me ☒ Reminds me

4.1 – What was it that felt familiar?

☐ Not so good times spent on the sea side ☒ Good times spent on the sea side

5 – How much did you enjoy the dish? (1-did not enjoyed at all; 5-enjoyed very much)

☐ 1 ☐ 2 ☐ 3 ☒ 4 ☐ 5