School of Hospitality, Culinary Arts and Meal Science

Örebro University

Flavour combinations in meals

A systematic review of reasons for pairing flavours

Date: 30-06-2020

Course name: Culinary Arts and Hospitality Science, Second Cycle, Independent Project

Course Code: MÅ602A

Test Code: M100

Grade:

Author: Karlström, Daniel.

Supervisor: Wennström, Stefan.

Examiner: Marshall, Matilda.

Date for grading:

Abstract

A selection of articles and books were reviewed to find out how the topic of flavour combinations is approached in contemporary literature. While the concept of pairing flavours based on aromatic similarity has gained much attention recently, it has been suggested that chefs in practice motivate flavour pairing decisions mainly by tradition and prior cooking experience, and some of the same affective associations as other recipe creators. Cultural appropriateness is often overlooked as a motivation for flavour pairing but it might be the most prevalent motivation. Aromatic similarity or dissimilarity affect liking through the qualities of complexity and harmony, and which one is preferred is culture dependent. Alternatively, flavours can be seen as modulators of the intensity of other flavours or are perhaps perceived as new combined flavours. The influence from other sensory input continues to displace the role of flavour in food pairing and a multidisciplinary approach that more accurately accounts for the main motivations for combining flavours is necessary for further research.

Key words: Aroma, Pairing, Aromatic similarity, Foodpairing hypothesis, Culture, Chef, Recipe

Concepts

Flavour: In this study the word flavour is used synonymously with the word aroma even though flavour technically is the sensation of both aroma and taste. Although the words flavour, aroma and taste describe different sensations, they are used interchangeably in colloquial language and notably even by experts. It is common practice for the perception of aroma to be referred to simply as flavour in literature, and so it has been here as well.

Taste: In this study the word taste is used as an umbrella term for the five primary tastes: sweet, salt, bitter, sour and umami.

Food pairing: The act of combining ingredients based on any sensory characteristics or any other factors.

Flavour pairing: The act of combining ingredients by aroma.

List of content

Preface

After working some years as a chef, I became familiar enough with cooking techniques to the point where I only read basic recipes to get an overview of the ingredients. After encountering thousands of recipes, only different in some of their ingredients, I began to wonder. Why were the ingredients chosen to be combined in a dish? I recognised that some ingredients gave texture or substance to a dish, others colour, but more often than not, the characteristic feature of a dish was from a flavourful ingredient. That thing that pulled me in, that made my mouth water and my stomach rumble was the quality of flavour.

The modern culinary chef has an almost limitless opportunity to change the characteristics of food. With a few hours in the kitchen the skilled professional can transform the texture, colour and taste of a food into something completely different. However, a creative bottleneck lies in the aromas. They are the basic elements that the chef has to work with. They are not dismantled and made anew, but only combine or change intensity. Aromas are constants in a world of change.

I wondered why flavours fit together, what motivation recipe creators had for combining them. A simple search gave no clear answer, and I realised that I was not alone fumbling around in the dark. I needed to dive deeper. I wanted to assemble current research into a clear picture, and place that image on a backdrop of what other fields of research, professional chefs, amateur cooks, food writers and recipe creators could tell us. This is an exposition of why recipes are made the way they are. Why flavours are paired and how it relates to compositional cookery as a whole.

Introduction

What makes food out of produce is the act of combining ingredients. But why do chefs combine particular ingredients, and keep others separate? Previous research has explored the intricacies of pairing tastes extensively, and pairing colours and shapes seems to be almost artistically intuitive, while pairing aromas is neither a well explored research subject nor an obvious intuitive skill. Can the same dominance and harmony systems that guide professionals in combining other sensations be used to adequately explain the reasons for pairing smells? When we combine ingredients, we can be inspired by a culturally learned combination or an intellectual system (be it scientific or not). Alternatively, we can attempt to create something intuitive, while probably drawing upon past experience from eating and cooking. Regardless of what might have inspired us to combine a set of ingredients, there seems to be a lack of awareness of our underlying motivations. To develop culinary arts further, and make culinary knowledge more structured and teachable, this knowledge gap needs to be filled. As modern cooking strives for perfection and efficiency, there is no place for misconceptions in culinary precisions. If progress is to be made, motivations for flavour pairing should be studied with the same accuracy as chemists study the forces involved in chemical bonds. This thesis was written to give chefs an overview of the many approaches to flavour pairing and to further understanding of the role of flavours in the interconnected context of food pairing so that pitfalls may be avoided. It can also be read by anyone interested in flavour pairing to become more familiar with what progress researchers and culinary professionals have made recently, and to gain a deeper understanding of flavour combinations in general.

Relevance for Culinary Arts and Hospitality Science

With recipe creators competing for recognition and having more tools at their disposal for producing creative dishes that challenge traditions, it becomes more important than ever to understand the motivation behind flavour combining. Chefs face an ever-increasing pressure to innovate to stand out from the competition.

Flavour pairings happen at an intersection between artisanal, creative and scientific knowledge and skills. The Five Aspect Meal Model (FAMM) is a central model featured in Culinary Arts and Hospitality Science (Gustafsson et al., 2006). The model breaks down the meal experience into five aspects, the atmosphere, management control system, room,

meeting and product. The theme of this study is relevant to the subject because it concerns the intersection where product meets man as a cultural and physiological creature. It is in a way a continuation of a branch of the FAMM model, because as motivations for pairing flavours are revealed, the flavour component of the product aspect is divided into its own aspects.

It is critical for all meal experiences that the flavours combined in the dish are satisfying for the guest. Nonetheless the subject is shrouded in mystery. It would be valuable for food science researchers to clear the fog of war around flavour combinations. The School of Hospitality, Culinary Arts and Meal Science at Örebro University has previously conducted research about combining food and drink (Nygren et al., 2017), but little has been done in the way of combining food with food. When food and drink is combined, the beverage offers a constant, the food is coupled with its flavour notes. Food flavour combinations are different because they offer vast possibilities of combining clear expressions of flavour. It is the base flavours that are combined, not the offshoot flavour notes, as it is in wine pairing. It would be valuable to invest time researching if systems can be developed for culinary chefs to determine food-food combinations in the same way that such approaches have been attempted for the sommeliers food-drink combinations (Harrington, 2005). In doing so, culinary craft knowledge becomes understood as scientific knowledge.

Theory

Flavour pairing is a complex subject that cannot be discussed in isolation from the wider context of food pairing. According to Galmarini (2020), establishing rules for combining food can be difficult and sometimes ends up contradictory. Tradition as well as other demographic factors are often overlooked when researching flavour combining. In order to be as thorough as possible, the main reasons for combining food were researched and synthesized into this multidisciplinary theory.

To start off, an overview of the practical reasons for combining food is presented. Obviously, the need for nutrition is the base purpose of eating, and therefore nutrition must be considered as a cornerstone in food pairing. On top of that, there is a layer of local accessibility to produce, economy or what is easy to acquire, and finally what ingredients are necessary for desirable chemical reactions in recipes. Through history, these practical reasons that meet

physical needs are transformed to cultural reasons that meet social needs. Functional habits over time become patterns that can be used to express group belonging.

Intertwined with our physiological need for sustenance is the ability to feel pleasure through the medium of our senses, which becomes a goal in itself. Sight, taste, touch and hearing are the less mysterious kin of smell. The other senses can even incongruously be a motivator for combining flavour. That is why they also need to be accounted for when discussing flavour combinations. Finally, flavour pairing systems, recent research trends and challenges are discussed as a background to the aim and research questions of this thesis. The following is meant to provide a framework for understanding flavour and pairing in a physiological and social context, so that contemporary data can be interpreted.

The practical reasons for combining food

Nutrition

In certain cases, it is not a stretch of the imagination to picture an origin of practicality for traditional combinations. For instance, a combination of the four basic food molecules: proteins, carbohydrates, water and lipids make for a nutritious meal, and a healthy diet will necessarily also include a sufficient number of vitamins and minerals (Livsmedelsverket, 2021). Some ingredients seem to be included in everyday recipes just because of their nutritious content, as meals are generally built on a base of carbohydrates as in rice, root vegetables or pasta (Rozin, 2000, p. 139). Aromatic qualities of foods help people identify what they are eating and creates concepts that meanings can be associated with. Perhaps flavours became causally associated with the health benefits of eating their sources, and yet researchers have not fully understood the complex relationship between flavour and nutrition (Shepherd, 2013, p, 228). Although flavours can be added to make bland foods interesting, nutrition has been the main reason for flavours being combined in literature before the modern era (Albala, 2003, p. 219). Historically, principles of dietary regimes and medicinal properties seem to have been more important for food pairing than sensory pleasure.

Accessibility of produce

Food habits have until recently been entirely dependent on the local fauna and seasonal flora (Bode, 2000, p. 28). The climate, humidity, rainfall, sunshine and frost freeze depending on

elevation in relation to the equator dictates what possibilities life has to exist locally. The soil and seasons bolster some food production methods and foil others. This is the basis of all regional food selection (Bode, 2000, p. 30). How the climate has impacted cultural food habits is expressed with clarity in the three gastro-geographical belts of the pre-globalised world (Bode, 2000, p. 43).

The northern belt made use of grain, root, fish, game, pig and cattle. The diet of people in northern Europe and societies horizontally aligned across the earth has been bread, vegetable, fish and meat. The beverages in this belt were all originally grain based (Bode, 2000, p. 43).

The middle belt contains many countries that are so called "food cultures", a wider variety of vegetables make varied ingredient lists in these places. The diet is generally rice based, with beverages made of fruit, and non-alcoholic drinks such as tea and coffee. Goats and sheep were originally the domestic animals of lower Europe, which brought about cheese as a staple in the diet (Bode, 2000, p. 44).

The southern belt draws its line through the upper part of Africa, above India, South America and Australia. The belt is represented by heavy use of herbs and spices, as well as a typical vegetarian based diet. It is hard to generalise more, as the many varied cultures in the southern belt have been influenced by European colonists and immigrants, and in part taken up food habits from these. The upper belts have also borrowed from the southerners, adopting staple foods such as peppers, potatoes, tomatoes, cocoa, tea and coffee (Bode, 2000, p. 45).

Despite a difference in geographically available ingredients, most cultures reach satisfying flavours through a similar approach (Rozin, 2000, p. 135). Flavour combinations are used pervasively; these so-called flavor principles are strong, distinctive seasonings that are pleasing for those within the group and recognisable to those outside the group (Rozin, 2000, p. 135). Rozin (2000, p. 136) calls the structural use of specific seasoning ingredients within a culture "flavour systems". She divides the ingredients into the categories of flavourful oils or fats, liquids and other ingredients that serve no other purpose than providing flavour and is usually added in relatively small quantities (Rozin, 2000, p. 136).

Economy

The cuisine of any given culture is affected by the economy (Grimm, 2007, p. 68). Sometimes a product is accessible in the broadest sense but is not an economically sound choice. This is more often the case today for those that are not part of the highest one percent earners. For the other end of the spectrum, poverty has been a driving force in creating new flavour combinations. As Bode (2000, p. 196) puts it, when you only eat potatoes every day, you think of ways to vary their flavour. Economic consideration has always been an important factor in shaping food habits. In the use of what has been cheap or free lies the basis of most compositional cooking (Bode, 2000, p. 196). During periods of food scarcity people would try anything that seemed edible, when food sources were plentiful, they could afford to be selective and pick food that was known as enjoyable and less time consuming to access (Bode, 2000, p. 30). In this way, desperation has been a motivation for creating many well-established dishes.

Necessary chemical component in a recipe

Sometimes adding an ingredient alters the chemical composition of food, making its inclusion necessary regardless of flavour. In a simple example, yeast is needed to make bread. It is particularly noticeable when an ingredient that a culture takes for granted is not available. The ancient Egyptians had to use dates in their pastries as they did not have access to refined sugar but desired a sweet taste (Alcock, 2006, p. 41). Another way in which an ingredient may be necessary in a food is in the form of a preservative. Using sugar, acid, salt and oil to preserve food is a common practice all over the world, but it is especially vital as a survival strategy in climates with extreme seasonality. In Scandinavian cuisine, the winter months made pickled, salted and fermented foods a staple part of the diet (Bode, 2000, p. 83).

The history of combing flavours

The evolutionary purpose of the senses was not the pursuit of hedonic pleasure but to help humans navigate the world and survive. For example, our ancestors would have used a sophisticated sense of smell to judge the ripeness of fruit (Shepherd, 2013, p. 226). As a byproduct of sensing valuable and dangerous foods, aromatic qualities that were not relevant to food appropriateness could be picked out. Flavour pairing based on motivations of aromatic compatibility seems to be almost absent from ancient history, what is more prevalent is flavour pairs as cultural constructs.

Culinary historians are able to differentiate if food is eaten out of necessity or flavour preference only by looking at what food choices seem irrational when considering what is available in the local environment (Outram, 2007, p. 39). In this line of thinking, Roman demand for spices from the east, along with the spice rush of the age of exploration is clearly done out of neither necessity nor habit of cultural cuisine, but rather a desire for certain novel flavours. Before the rise of cookbook writing that gained momentum in Roman times, almost nothing is known about recipes (Wilkins & Hill, 2006, p. 277). It is only known what ingredients were used, but evidence for how they were combined into dishes is unusual to say the least (Outram, 2007, p. 59). Cooking was not a task for the literate, so traditions were seldom written down but passed down by word of mouth instead (Bode, 2000, p. 57). The ancient Greeks had a tradition of combining certain flavours, even if historians cannot with any certainty say that they had developed a system with rationale. In the most sceptical voice that can be mustered, Bode (2000, p. 60) writes that at the very least their early compositional cooking would have been motivated by a need for flavour variety. A new herb or fruit could be added to the porridge each day to break monotony. This type of behaviour could be considered the beginning of compositional cookery in Europe (Bode, 2000, p. 60). If there ever was a period without strong cultural pressure on mixing certain ingredients and not others, what principles were eventually established might as well have been based on random habits and not on insights on aroma affinities.

The Romans inherited some dishes from the Greeks, and geographically had access to many of the same ingredients as the Greeks. What is apparent is that the Romans in their quest for new gastronomical heights of indulgence had acquired a taste for powerful flavours and abandoned those natural (Bode, 2000, p. 71). They drenched their protein in strong sauces like liquamen and dipped their carbohydrates in hot spices like imported pepper (Alcock, 2006, p. 236). In an overview of the cookbooks of the time a total of 87 spices were counted, which comparatively overshadows the amount of spices that are in use in our time (Shepherd, 2013, p. 209). That this many spices had names and were differentiated by aroma suggests a certain sophistication in early European flavour systems. The flavour combinations of the time may have been passed down to today, solidifying their status as good combinations with each passing generation.

Some historians have seen medicine as the root of European culinary practices (Albala, 2003, p. 219). In ancient literature, ingredient selection is almost exclusively motivated by health

promotion. Dietary regimes were prescribed based on the humoral theory, which stated that the body was a mix of blood, yellow bile, black bile and phlegm. Having too much of any of them would be a cause for affliction of diseases or temperaments. Different foods were believed to have an affinity with one or the other of the four elements and were recommended to correct any imbalance accordingly (Alcock, 2006, p. 127). Wet and cold foods would be paired with dry and hot spices, in the humoral meaning of the words. Humoral allusions along with any medicinal, aphrodisiac and laxative properties was stated as a reason for choosing foods (Wilkins & Hill, 2006, p. 58).

When survival had been accounted for, food would have been chosen by taste preference, or in the case of the wealthy food would be chosen for diet or as a display of social status (Alcock, 2006, p. 228). The medieval cuisine of the wealthy set the table with exotic and expensive rarities that were combined in innovative ways, not too different from today's forefront of gastronomy (Rozin, 2000, p. 141). Since ancient times, eating has not merely been for satiety, but for affirmation of kinship, civic and religious bonds through commensality (Wilkins & Hill, 2006, p. 63).

Culture

It is not always that people eat in a way that would fit the biological narrative, in fact they often pick their food for qualities that seem to go against their survival instinct. Such are acquired tastes, where a sensory input originally indicated danger, it becomes a desired trait. The bitterness of coffee, the butyric acid in American chocolate reminiscent of vomit, the stinky smell of intentionally spoiled cheese, in uncultured man these features are warning signals. Regardless of how close our food choices are to our congenitally intended preferences; meals have an added cultural value. Taste has not simply been a matter of what is favourable to the palate, but also a matter of fashion, a public display (Outram, 2007, p. 60). In this way flavour combinations are used as a signal for group solidarity (Rozin, 2000, p. 137).

Different cuisines can be described in terms of culturally different flavour principles. These principles consist of unique combinations of ingredients that appear in many different dishes within a given culture (Prescott, 2012, p. 150). Prescott (2012, p. 149), gives the example of how Thai curry is made up of ginger, fish sauce and lime in contrast to Indian curry which includes ginger, cardamom, cloves and turmeric, and how Moroccan cuisine is known for the

omnipresent spice blend Ras El Hanout. Cooking in the flavour principle spice blend psychologically justifies new food as acceptable, acting as a buffer against neophobia. The combinations that are shown to us in childhood become part of our national identity (Shepherd, 2013, p, 12).

Tradition is usually a consequence of exposure to and availability of certain ingredients (Galmarini, 2020). Ingredients that grow in the same terroir are often eaten together on the same plate regardless of chemical composition. Certain spices are perceived as flavour landmarks even though they are now globally available. Such flavour landmarks are cumin for the Middle East and Mexico, ginger and star anise for southern China and caraway for northern Europe (McGee, 2020, p. 268). In comparison with African and Asian cultures, Western civilisations use relatively few vegetables, fruits, meats, and fish (Bode, 2000, p. 30). Western haute cuisine achieves complexity with few ingredients by using highly developed methods of preparation. The more a culture relies on plant foods, the heavier is the use of seasonings, and vice versa for cultures that rely to a greater extent on animal foods (Rozin, 2000, p. 137).

Throughout history, food habits have been regulated by religious taboos. Religious eating disciplines may have been rationalised by practical or health-related reasons at first (Bode, 2000, p. 216), but it seems impossible to trace an origin of many of these habits, they have become a way to show group affiliation (Prescott, 2012, p. 143). In western society a cultural revulsion stops people from eating cats, dogs and rodents. Curiously, it is most often animals that are forbidden fruit in the rest of the world. Ancient taboos also include eating different kinds of meat, which is avoided due to a sentimental relationship to animals particularly when those animals are pets or due to food safety or mythical reasons. If a food had a symbolic link to a myth, it would sometimes be avoided by priests. Another food taboo that appeared now and then was beans, in one motivation because its aroma can be reminiscent of semen (Alcock, 2006, p. 242).

In certain cases, rules are placed to disallow combining ingredients. Eskimo tribes consider it an abomination to eat meat from land and sea at the same time, and some Jews will not eat meat together with dairy products (Bode, 2000, p, 217). Culture has a way of creating expectations for flavour combinations by making us compare what we are eating to the experience of past compositions (Prescott, 2012, p. 145).

Through social eating norms, a different kind of regulation takes place. The soft taboo does not state what produce is forbidden to eat, but what produce is forbidden to eat together. In this way, a desert food condiment on a main course meal can create the same disgusted reaction as does the eating of a dog or cat in western culture. Soft taboos stress the importance of context. In a study, participants were told they were eating smoked salmon flavoured ice cream or mousse respectively. The mousse was clearly not as disliked as the ice cream, even though the content was the same (Yeomans et al., 2008). When people are introduced to novel flavour combinations, they evaluate them through their cultural lens. As man is a culture generating creature, flavour science needs to take that into account when designing research.

As the importance of context for flavours that are naturally found in sweet or savoury ingredients has been demonstrated (Yeomans et al., 2008), we can see how flavour combinations correspond to the modern classical menu structure. This turn order of eating originated in the private sphere of the European aristocracy in the 1600, 1700 and 1800s (Bode, 2000, p. 109). This tradition culminated in the public sphere in the menus of popular restaurants and hotels. When multiple course tasting menus are not present, the basic order is condensed to starter course, then main course followed by dessert (Bode, 2000, p. 109). The order of eating now seems so deep rooted that it cannot be questioned. This translates to the inclusion of flavours in dishes because flavours are expected to appear in a respective anchored array of dishes. Flavour combinations have to be considered in regard to their dishes' position on the menu. No matter how much two ingredients might fit together, if one of the ingredients is kindred with meat or fish, it is likely that it will be met with disgust if presented in a dessert.

Although a combination can be motivated by either food pairing theories or experience, it cannot be distinguished as independent from culture if it does not possess a significant degree of novelty. Any traditional ingredient pairing cannot be isolated from culture. This fact impairs our options when developing research for food pairing theories. Can novel combinations stand a chance at being preferred over established combinations with the exception of some rare instances? Though it is technically possible to combine any set of ingredients on a creative level, the reception of radical combinations will likely be a sceptical one. Attitude towards combinations are controlled by habits and cultural exposure. The

occasions where novelty is accepted are generally in settings of consumer tests and haute cuisine (Lawless, 2000, p. 92). These environments enable the imaginative eater to attempt to drop their cultural bias for a brief moment and attempt to approach flavours with an open mind.

What flavours are and how our sense of smell perceives them

Smell is a molecular sense; it detects volatile molecules around us and makes us aware of their presence. As molecules are breathed in and out with air through the mouth and nose, they pass two sensitive pieces of skin inside the head, where around four hundred different odour receptors encounter them (McGee, 2020, p. xx). The receptors are attuned to picking up different molecules and are triggered in different group arrangements whenever a whole smell is encountered. As a 4-digit lock has 4000 possible combinations, the number of combinations 400 or so receptors could theoretically be arranged in is exponentially more. Obviously, detecting every smell is not useful for survival, and so smells that are not relevant to us pass us by unnoticed. People do not smell the nitrogen, oxygen, and carbon dioxide in the air, or the hydrogen in water, because these are always present, rather the sense of smell excels at smelling change (McGee, 2020, p. xxi). Smell is a selective sense, there needs to be a filter to prevent information overload, the filtering out of uninteresting aromas can be compared to how the brain filters out the nose from our field of view, even though it is clearly visible. After all, the environment contains thousands of different odor molecules, but we only need our sense of smell to identify those of behavioural significance (Shepherd, 2013, p. 89).

What is now known as orthonasal smell has often been viewed as synonymous with the sense of smell at large. It is the main way we smell when pulling volatiles in the air through the nose by normal breathing or sniffing (Shepherd, 2013, p. 18). The other sense of smell comes into effect when stimuli enter the mouth. It is called retronasal smell and happens as air in the back of the mouth is breathed out through the nose (Shepherd, 2013, p. 18). As orthonasal smell works in tandem with vision and hearing, retronasal smell is experienced with taste and texture.

Shepherd (2013, p. 62, p. 86) claims that smells that connect with receptors in the nose are processed into images by the brain in much the same way as raw light information is perceived by the eyes and reconstructed into meaningful spatial images in the brain. Without the brain's interpretation, nothing really smells like anything. It is the receptors which humans

are equipped with, along with the categorisation that language permits, that make smells out of molecules. The receptors can be thought of as locks and corresponding volatile molecules as keys. To continue along the analogy of vision, when we recognise a face, it is not any one part of the face that makes it familiar but the whole of the combined parts together. If the eyes are blurred out, a face quickly becomes unrecognisable, and similarly, if a key aroma compound was absent a smell could not be recognized, and should only the key compound be perceived instead the whole image of the smell could not be reconstructed (Shepherd, 2013, p, 82).

Sensory qualities of food

As flavour as a concept is confused with many other reasons for combining food, it is important to recognise all these other reasons in order to discuss flavour combinations on its own (Spence et al., 2015). In Harrington's (2005) hierarchical perspective, flavours are the last thing to consider among all the reasons for pairing food. Even when highly aromatic ingredients are added, they are not usually added as pure extracts. Some ingredients are added for their substance, or one of the sensory reasons other than smell, other ingredients are added just for their aromatic value, some others still, for example celery, are aromatic ingredients used both as a primary ingredient and as a flavouring (McGee, 2020, p. 257).

Texture

The skin of the lips, cheek and inside of the mouth are filled with somatosensory receptors in high density that provide information about feel, texture, pain and temperature (Shepherd, 2013, p. 128). To imbue ingredients with the right feel is crucial for the acceptance of most components, as with the creaminess of a sauce, or the crisp surface of potato chips or fries (Shepherd, 2013, p. 131). The mouthfeel of food makes huge contributions to the overall impression of a dish. Therefore, chefs will often use textural variety as a starting point when creating recipes. In this way, a cold ice cream could be chosen as accompaniment for a hot chocolate lava cake with a spongy outside and liquid inside (Lawless, 2000, p. 101-102). According to Lawless the combination of crisp texture and juiciness is often particularly appreciated, this would be because of the complexity that contrasting textures offer (Lawless, 2000, p. 101-102).

Sound

Hearing is the sense that is usually overlooked whenever the sensory aspects of a meal are discussed. Sound is an indispensable part of being able to appreciate crispness in a food, and as such should not be discounted (Shepherd, 2013, p. 144). There have even been attempts to develop standardised language to differentiate between different experiences of brittle foods. Applying the word crisp to high frequency sounds above 5 kHz, crunchy to frequencies between 1 and 2 kHz and crackly to lower frequencies (Shepherd, 2013, p. 145). Other sounds that food makes change with viscosity, or in the case of drinks with carbonation (Lawless, 2000, p. 93). Food can be loud when it is seared, become quiet when it rests on the plate, only to again be loud within our head as our jaw crushes and our teeth grind.

Visuals

Humans are visual creatures primarily, in the manner that our eyes help us navigate the world and enacts a baseline for our survival capabilities. As such, it is not surprising that colour and form make an important contribution to food palatability, food plating is even considered an artform comparable to painting by some (Prescott, 2012, p. 162). Therefore, the expression – we eat with our eyes.

Visual cues create expectations for what is to come flavour-vise. Vibrant colours can be taken as cues for freshness and energy content as with ripe fruit or be deemed beautiful like the colours in a painting, and the outlines and shapes provide both boredom breaking aesthetics and details about amount and substance. The intensity and aroma direction a flavour takes on is in some cases already partly regulated at first sight of the component (Shepherd, 2013, p. 138).

Primary taste

Despite the fact that the word taste is often used in conjunction with ingredients, there is no coffee taste, orange taste or chocolate taste other than the taste of sweet, bitter, sour, salty and umami (or possibly other unconfirmed tastes). What we perceive as coffee, orange or chocolate, and all other foods as well, is really aroma and not taste (Prescott, 2012, p. 20). In an almost illusory way, flavour is experienced in the mouth when aroma molecules ascend the nasopharyngeal passage at the back of the mouth and trigger olfactory receptors in the nose.

The combined experience of taste and flavour is so well integrated that the illusion is not fully broken until our sense of smell is impaired. What remains then is the primary tastes.
There are five of them, although taste receptors for fat have been found in rats (Prescott, 2012, p. 37), and hypothetically the taste of fat and many other subtleties could be classified as primary tastes in the future.

The five primary tastes sweet, bitter, salty, sour and umami all add great hedonic value to our meals, but in their evolutionary origins they had developed to signal different things. This has directed the range of their use. The significance of taste is that saltiness is essential for maintaining salty body fluids, sweetness alerts us to high sugar content, which in turn indicates high energy as in mother milk and fruits, sourness warns that a food may have gone bad, bitterness warns of toxic substances and savouriness signals high-energy (Shepherd, 2013, p. 121).

Sweet

Humans have evolved to like sweetness for the energy value it signals (Prescott, 2012, p. 36). Curiously, it is rare that something would be perceived as inedible due to too high sugar content, despite the fact that high contents of bitter alkaloids, acids or sodium chloride quickly renders food inedible. When a new flavour is introduced via a sweet food, there is a tendency to adopt it as a liked flavour (Prescott, 2012, p. 69).

Bitter

Bitterness on the contrary, is a signal for danger since many poisonous plants are bitter. This is not a universal rule, since many edible vegetables are also bitter (Prescott, 2012, p. 42). The appeal of bitterness is not commonly seen in children as the way the appeal of sugar is, it is rather an acquired taste that is adopted with age as we are gradually exposed to bitter foods. The average child would not react positively to bitter tasting coffee, beer or high cocoa percentage dark chocolate, and yet it seems to be favourites that are regularly consumed among adults (Prescott, 2012, p. 42).

Sour

High levels of sourness can elicit a negative reaction in the same way as bitterness. Acidity tends to be hated on its own, but loved together with sweetness, perhaps because of how the tastes balance the others intensity when mixed. A possible explanation for this circumstantial

preference could be the lifecycle of fruit. When a fruit is either unripe or beginning to spoil, it tends to have higher levels of acidity. When a fruit is just ripe, it tends to have some acidity, but be a lot sweeter as well (Prescott, 2012, p. 43). Detecting sourness helps to identify food that is safe from spoilage and ready to be digestible. While various acids naturally occur in the food we eat, stronger acids are outright harmful. Even something as innocuous as lemon is not popularly consumed on its own. Sourness becomes palatable when balanced by other flavours. Sourness is used to add dimension to food and is highly liked in the right context (Prescott, 2012, p. 44).

Salt

Sodium is an essential mineral in the human body, eating salt therefore is a dietary necessity. The ability to detect salt can also save lives when it risks being overconsumed, as in differentiating saltwater from freshwater. Nevertheless, humans find the sensation of salt to be so pleasurable that sodium requirements are surpassed by an intake of more than twice the recommended amount (Prescott, 2012, p. 38). The reason is that salt functions as a flavour enhancer, adding flavour impact to dishes. In the same way as the process of salting-out is used in laboratory settings, salt will react chemically with the food it is scattered on (Prescott, 2012, p. 39). After the period of our lives we spend devouring baby food, few of us would accept an unsalted dish, as it is in most cases viewed as flat, boring and unpalatable.

Umami

When we experience savouriness, we are really reacting to the signal for a diverse group of acids, mainly the amino acid glutamate and nucleotides. Glutamic acid is present in all proteins, but particularly rich in some. As such, savouriness is a signal for high-energy food (Shepherd, 2013, p, 121). Glutamate-rich ingredients can be found in cuisines all across the world. Many processed animal products are particularly rich in umami taste. In western cuisine, umami is most obviously incorporated into food by adding vegetables, meats and mushrooms to the stock of stews, sauces and soups (Prescott, 2012, p. 40). This is an important reason why certain ingredients are included in recipes. We can see how different geographical conditions gave access to different ingredients that were used in a similar fashion to concentrate umami taste. In a non-European context, asian cultures developed ways to ferment soybeans, an ingredient which did not reach Europe until later in the 16th century. Asian cultures also developed fermented fish sauces to add umami flavour independently of the roman tradition, much like the roman garum it is used copiously (Prescott, 2012, p. 41).

Umami tends to resonate well with dishes that are supposed to be filling and savoury but can be viewed as disgusting when used in a sweet dish. Much like the other primary tastes, umami is appreciated where it is deemed to be appropriate.

The cook needs to take into account what taste goes with what taste, texture and odour (Prescott, 2012, p. 45). Certain tastes are sometimes thought to be opposite poles, but the four classical tastes, that is the first four mentioned, all suppress one another when combined (Lawless, 2000, p. 95). The mere act of mixing can be a force of balance, or an act of masking depending on the perspective. The same principle is true for aroma, the more defining contributor to flavour.

Aroma

Since the 1950's attempts have been made to create a classification system for odours. Prescott (2012, p. 21) points out the futility of categorizing odours as simple ingredients contain hundreds of chemical compounds which can potentially be perceived in notes, smells from food in different aroma categories. To further complicate things, it is the combination of these chemical compounds that trigger our brain to recognize the smell of the food item (Prescott, 2012, p. 21).

Flavour compounds have previously been divided into three groups (Lawless, 2000, p. 96). Nominal compounds are key aromas that are required for an ingredient to have its characteristic smell. Congeners add a variation to a theme, and diversifiers add to the aroma in more abstract but noticeable ways. To add to this view we could also say that any given flavour also contains compounds that add to the whole in a more ethereal and scattered way, on their own being below the threshold for recognition. In the smelling of an apple, nominal compounds would add apple smell, congeners would add notes that hint to apple variety and diversifiers would add a feature like fresh (Lawless, 2000, p. 96).

When odours can be perceived separately as notes, they can have the effect of suppressing and hiding other notes. When flavours are well-blended they are less discernible and instead take on a new role close to how blends of compounds creates the combined impression of a natural product (Lawless, 2000, p. 96) Why then, do we combine certain flavours and not others? There are two initial aspects concerning flavours in combination that apply regardless of choosing a cultural, intellectual or intuitive approach; a positive experience and harmony.

Positive experience

What is generally meant by a good combination is that the combined flavour profile should provide a positive experience for the eater. The experience of eating two foods together should also be more positive than eating the foods separately, as to not render the combination pointless. Harrington (2005) refers to this central objective of pairing as synergy. The hedonic value of food stems from the person, not the food itself (Prescott, 2012, p. 11). It may seem strange therefore, that so much focus is given to the food, and so little to culture as much as it regulates human behaviour. Though culture provides the framework for which foods are eaten together, there are individual variations in food habits between groups of people, or even between family members (Prescott, 2012, p. 10). Variations in psychological and genetic-make up keeps food selection from becoming fixed within cultures (Prescott, 2012, p. 13).

During our lifetimes, likes and dislikes adapt as we learn to associate flavours with the accompaniment of nutrients (Prescott & Monteleone, 2015, p. 372). An ongoing tug of war of evolutionary functions pulls us between exploring new food sources in times of scarcity and avoiding new food sources to minimize the risk of being poisoned (Prescott, 2012, p. 12). The most likely explanation of why we like food puts sensory pleasure as the motivation to consume something edible as a response to the information gathered by the senses (Prescott & Monteleone, 2015, p. 372). The sensory information is filtered through a mental model which we use to determine what is good to eat. As Alcock states, in childhood a prototype of favoured foods is created, later on in life all new food is compared to this original template (Alcock, 2006, p. 228). Genetic inheritance, maternal diet, child-raising practices, learning, cognition and culture all impact this (Prescott, 2012, p. 12).

A fundamental idea behind combining ingredients is to add levels of complexity by playing of harmony and contrast between attributes (Lawless, 2000, p. 93). Research has suggested that complexity is a characteristic of a good combination, but one that depends on the complexity acceptance of the consumer and conferring to product qualities (Paulsen et al., 2015). The inclusion of additional flavours may add cumulative value. Traditional cuisine often includes multiple sensory stimuli that enhance one another in a congruent way (Shepherd, 2013, p. 122).

Harmony

A good combination is often defined with terms like harmony, balance, match and ideal pair. This refers to a school of thought which advocates the idea that neither flavour component should dominate the other in intensity (Galmarini, 2020). The most commonly mentioned principles of food and wine pairing are overall flavour intensities and taste balance (Paulsen et al., 2015). The degree to which we have previously been exposed to flavour intensity determines our optimal level of intensity, called a bliss point (Prescott, 2012, p. 146). Our senses will attune to properties of the food we usually consume, defining our benchmark.

Lawless (2000, p. 92), views the meal as the struggle between harmony and desire for sensory contrast in things that are to be consumed together or in short successive time intervals. Sensory combinations happen where neophobia, fear of the new, meets with neophilia, interest in the new (Lawless, 2000, p. 92). We defy our sense of comfort in previously tried foods in an effort to find new experiences. This conflict between two opposing drives is referred to as the omnivore's dilemma (Lawless, 2000, p. 92). In an attempt to treat our ambivalent condition, we establish common themes in our cuisines that act as anchors for our voyages into new flavour inclusions. It has been proposed that sauces act as a representation of sameness while allowing for variations on a theme (Lawless, 2000, p. 92).

The effect one flavour has on another can be seen as modulative, in that a flavour can bolster, suppress or hide the intensity of another. In a singularly clear example, lamb flavour is justified to pair well with herbs because of the herbs' ability to mask unpleasant smell (McGee, 2020, p. 84). The peculiar smell of lamb and mutton has a sour and sweaty quality that tends to disgust outside the shelter of lamb eating cultures (Prescott, 2012, p. 146). The aroma stems from ethyl- and methyl- octanoic acids in goat bodies (McGee, 2020, p. 87). The bodily flavour is concealed by common pairings like rosemary, mint, oregano and thyme. Following the same principle, other strong and distinctive flavours are also paired with lamb, such as fresh and dried fruit. In the case of lemon, we might be tricking our brains that the sour component of lamb flavour came from the lemon.

The creative talent of the chef is required so that flavours are balanced in a satisfactory way (Schafheitle, 2000, p. 275). Schafheitle emphasizes that chefs arrive at flavour pairings through learned combinations within the profession, as well as intuition. Flavours should be clearly identifiable, and contrasts provide an interesting eating experience for the guest

(Schafheitle, 2000, p. 309). In fact, it is often that disharmonious ingredients are added just to break up monotony. An example of such a foil or palate cleanser is cool chutneys to hot curries, or pickled ginger to sushi (Lawless, 2000, p. 93). In Schafheitle's general guidelines for designing a meal, built on commonalities between the approach of four esteemed chefs that were interviewed, varying sensory inputs was a defining motivation for choosing ingredients (Schafheitle, 2000, p. 273). Flavour variety and flavour dominance was mentioned. Complex flavours were to be avoided, but this is not applicable outside western culture. No details about flavour beyond that point were agreed upon. One chef was disgusted with the prospect of fusion cuisine's way of combining cultural seasonings with dishes from other cultures (Schafheitle, 2000, p. 277).

The Foodpairing hypothesis

Just like a dish is made out of a combination of ingredients, a smell is made out of a combination of many different molecules (McGee, 2020, p. xxii). It is not that we smell all the molecules in a given object either, it is just those molecules that are perishable and light enough not to be weighed down and escape into the air, that strike an accord that we recognise as a reflection of the object we are smelling. The sense of smell gathers aroma compound stimuli and our brain reinterprets the molecule mixtures as flavour images, so that we associate the stimuli with a property of a rewarding or dangerous situation or object (McGee, 2020, p. xxiii).

Gas chromatography - mass spectrometry, forthwith abbreviated as GC-MS, is an analytical method designed to identify substances in a sample (McGee, 2020, p. xxvi). The method makes use of both machine and human to catalog what molecules are present in foods and what they smell like. Using data compiled from GC-MS food analysis, François Benzi developed a hypothesis that data from GC-MS could be used to determine successful flavour combinations by looking at how much some of their volatiles overlapped. The more aromatic compounds two ingredients have in common, the better the match. Although what is recognised as ingredient smells consists of hundreds of individual aromatic compounds, not all are distinguished and only some are perceived as dominant and essential for the perception of certain flavours. Food pairing theory looks to these key aromatic compounds to determine the match. This idea eventually gave rise to the *foodpairing.com* website (Foodpairing, 2021), which caters to food and beverage industry professionals looking for flavour pairing inspiration and advice.

The *Foodpairing* hypothesis has since gained popularity among ambitious chefs but not without attracting some critics. In *Food pairing theory - A European fad*, de Keppler (2011) points out some flaws and repudiates the idea. First, the preciseness in breaking apart flavours and comparing aroma compounds does not translate well into how humans actually interact with food. As Prescott (2012, p. 27) also points out, using intricate flavour combination theories to determine a pair to later be evaluated by the blunt instrument that is the human nose can be problematic. After arguing that the ability to experience aromas in the average citizen has been overrated in the theory's premise, de Keppler (2011) moves on to attack the preposition that there is an innate natural fit between foods. Even if a pair of ingredients has a high score in compatibility, cultural bias will easily override a natural fit, suggesting that there is nothing to the notion of a natural combination. The critic also disputes the scientific validity of the project because of lack of transparency regarding the method. How should the scientist determine what to measure and compare? Should all compounds be measured or only some? Does an overall percentage of shared compounds precede quantity of compounds? Lastly de Keppler (2011) points out the lack of a scientific study that proves that flavour pairs that share more aroma compounds taste better, and that flavour pairs that lack shared volatiles taste bad.

A brief overview of the food pairing field today

During the twentieth century the demand for novelty in flavour has increased tremendously (Rozin, 2000, p.140). With the rise of molecular gastronomy and haute cuisine, a segment of the restaurant industry solely focuses on sensory pleasure and disregards nutrition and satiety. These restaurants success is dependent on their ability to create unexpected flavour combinations (Prescott, 2012, p. 15). At the same time, successful cookbook writers employ mouth-watering photography and tantalizing ingredient combinations to sell their recipes (Prescott, 2012, p. 15).

Progress in the food pairing field is hindered by lack of reliable methods to study flavour pairing in contrast to traditional sensory methods for testing one sample at a time (Galmarini, 2020). Another challenge is the choice of sample selection, it has previously been attested to be hard to control the variables and to get results that can be generalized. The exponential difficulty of conducting studies with multiple combinations of foods has left the food pairing field lacking standardized methodology. This is further complicated by the complexity of the

human element involved, which has locked the study of flavour combinations in a multidisciplinary approach (Galmarini, 2020).

In a western context, as cultures intermingle and food is so abundantly available that the reasons for eating food other than a need for sustenance take precedence, there seems to be a decline in neophobia (Scholliers, 2007, p. 334). Increasingly, novelty may gain leverage over tradition, or at least, there is an interest in culinary traditions outside the home culture. The elevated position of high cooking, the strange combinations of flavours in recipes of cookbooks and revered restaurants, the acceptance of ethnic restaurants, they all testify to the direction in which cooking is going (Scholliers, 2007, p. 356).

Attempts to classify flavours tend to fall short of being satisfactory. The chemistry of flavour and the mechanisms of smell is too complex to make it possible to condense aromas into primary elements in the same way as colour can be broken down into wavelengths and sound into frequencies. Food scientists, organic chemists, psychophysicists and wine tasters each have their own vocabulary for flavour components (Shepherd, 2013, p. 210). Shepherd (2013, p. 211) believes that smell is interpreted by the brain as "smell images" or "arbitrary irregular patterns of activity", which makes it difficult to describe smell with language as it is really an experience of an archetypal imagery concept. That is not to say that the image is meant in the way of visuals, but in the way that it is symbolic, in the way that symbols communicate directly to us and bypass linguistic understanding.

The close examination of beverage notes has led to the development of aroma wheel tools (Shepherd, 2013, p. 211), which recently have been used in conjunction with food-food pairing theories as we shall see (Briscione & Parkhurst, 2020). Even so, these aroma wheels are not used to match flavours in and of themselves and nothing is known about the combination of different aroma supercategories, which is perhaps peculiar as claims are being made about the relationship between specific aromas.

The weight of the influence culture exerts over flavour combinations prevents theorists from creating a streamlined uniform system based on chemistry and makes interdisciplinary work an obligation. It is the recurring struggle between a perspective of nature versus nurture. Because partaking in food and cooking is a cultural medium and an identity marker, nurture seems to have the lead (Wrangham, 2015). A flavour combination that is popular in one

human society, is not necessarily appreciated within the context of a different culture. And yet there are acts of combining that elicit something closer to a universal response. For instance, the act of combining orange juice with toothpaste. In that particular case, sodium laureth sulfate in the toothpaste suppresses the taste buds' ability to taste sweet, and enhances their ability to taste bitter (Colgate, 2021). The infamous combination turns common household items into something unfamiliar and harsh. But if the reason for a failed combination is not an unpleasant chemical reaction, it is safe to assume that it is more often than not a cultural reason.

Aim

The aim of this thesis is to investigate how the topic of flavour combinations in meals is approached in contemporary literature. This was attempted through answering the following questions:

How is the compatibility between flavours motivated?

What role does flavour play among other reasons for combining food?

Methodology

Choice of method

A systematic review was used to answer the aim of this study. A systematic review is a suitable method for gaining insight on subjects where experts disagree (Bryman, 2011, p. 102). Additionally, a systematic review is a suitable method for compiling large amounts of data on subjects where knowledge is lacking. If qualitative and quantitative sources should both be included in a systematic review is determined by the research question (Lizarondo et al., 2021). In this case, both qualitative and quantitative sources were included. The analysis method used in this study is qualitative, which is an appropriate choice when studying complex areas of research in need of theory development (Bryman, 2011, p. 371). In developing a research strategy, *SPICE* (SBU, 2021) technique was used to encircle what areas should be processed (Table 1). *SPICE* (SBU, 2021) is a step-by-step approach to formulate questions for finding evidence in existing research. In this study, two sources of literature were reviewed. First, peer-reviewed articles were selected in a systematic way with the help of a search matrix (Appendix 1). The selected articles were then evaluated for scientific quality based on (CASP, 2021), and put into an article matrix (Appendix 2). The important findings in the articles were then qualitatively analysed, summarized and merged into a new meaningful overview.

In addition, flavour recommendation books were used to give a complementary view on artisanal knowledge of flavour combinations. These books were chosen via convenience selection, although a systematic mindset was applied to achieve at least some level of representability (Appendix 3). Considering that cooking is not only a scientific endeavor, but also an art based on craft knowledge, flavour recommendation books offered an invaluable perspective on cooking that was closer to the practice of culinary professionals than what the articles could provide. Special care was taken in procuring sources with good critical and public reception, the selection was among the only relevant books that could pass these criteria in a field with almost nothing available. The data in the selected books was coded and interpreted with qualitatively thematic analysis method (Bryman, 2011, p. 528). In total, 7 articles were reviewed, and 4 books were analysed (Appendix 3).

Table 1.

SPICE technique for formulating research questions.

Setting	Perspective	Interest	Comparison	Evaluation
Cooking and eating, Primarily western society, 1995–2021	Food book authors, Food Scientists, Professional chefs	Flavour pairing motivation	N/A	Motivations and attitudes towards the interest. Theories and hypotheses.

Procedure

To begin with, a preliminary search was conducted to get an overview of the available research in the target area and to develop appropriate search words and criteria. This search was done in the university search engine Primo. This showed that the research in the area of flavour-flavour pairings is limited, as under 20 potentially relevant articles were found after reading hundreds of titles in several searches. The majority of research done on flavour is concerned with food and beverage pairing, specific food volatile compound profile identification, or flavour from the perspective of physics or psychology. Reviews in the research field were read which confirmed the impressions of material scarcity and further gave an overview of impactful articles and leading research. At this stage a procedure for screening titles was adopted. Articles that concerned single ingredients and not combinations of them, or were otherwise slightly off topic were not to be included. Articles concerning beverages, drinks, wine or beer also had to be excluded for the most part, as these studies mostly deal with other factors for pairing than aroma and also pairing between two complexed finished food products, which is not necessarily translatable to the pairing process in cooking that this study focuses on.

An information search consultant from the university library was consulted for advice for improving search techniques and understanding of the databases used in this study. The field of flavour science is multidisciplinary, encompasses many complex interlinking sensory stimuli and to make searches even more difficult, several words are used synonymously with flavour. Due to this the widest searches could not be so precise as to only include hundreds of articles, instead as many titles as time would allow were read in a very inclusive searchway.

The keywords flavour (British English and American spelling), aroma, odour, taste, food and ingredient were used synonymously by putting boolean operator *OR* between them (Appendix 1). Boolean operator *AND* was used in between the previously mentioned keywords and the keywords pairing, pair and combination. This searchway was used with slight variations across all the databases used. Depending on the available options for filtering and the number and relevance of search results, some keywords were not used, and additional ones were added (Appendix 1). The other keywords were after boolean operator *AND* the words motivation, food-food, computational gastronomy, artificial intelligence, computer, match, harmony, tradition, culture. The use of all keywords in all databases and search engines was determined to be redundant. Extra keywords were not included when they showed no promise of making search results more precise or yielded no new articles. The boolean operator *NOT* was tried in conjunction with the words beverage, drink, wine, beer, tea, coffee and taste. Keywords were when possible included as topics and not titles, as to not miss any important articles. A truncation (*) was used at the end of keywords, as to include possible inflections. Search results were sorted according to relevance.

The databases Web of Science and Scopus were used for an extensive search, additionally the search engines Google Scholar and Primo were used for a complementary search. After a varying amount of titles had been read on each website, the abstracts of the relevant titles were read. Out of the remaining articles, firstly the most relevant to the studies aim and secondly the most cited and/or cross-referenced titles were chosen. Among these, a further selection took place in an attempt at diversification of perspectives. The remaining titles were selected based on quality control (Appendix 2).

Inclusion criteria

The articles were selected based on a number of criteria. First, the material should be written in the English language. This was due to the author's language comprehension and to ensure a coherent use of technical terms. Second, the material should be available in full text for free for students enrolled at Örebro university. The material should also be an article written in a food related research area between the years 1995 to 2021. There was one exception to these criteria in the inclusion of the study of Kort et al. (2010), which is a conference submission and not a peer-reviewed article. The study was included because of its importance as an impactful cross-referenced study in the field and because it otherwise passed the quality control. Although only articles that concerned food-food pairings were used when possible,

food-beverage pairings had to be included to a lesser extent as there were not enough available relevant articles on food-food pairings.

In the quality control stage of article selection, criteria dictated that the articles should be peer-reviewed, this was ensured with the help of the website Ulrichsweb (Ulrichsweb, 2021). Additionally, the qualitative studies were examined according to the Critical Appraisal Skills Programme (CASP) checklist for quality control (CASP, 2021). The checklist asks the following questions which can be answered with YES, CAN'T TELL and NO. 1. Was there a clear statement of the aims of the research? 2. Is a qualitative methodology appropriate? 3. Was the research design appropriate to address the aims of the research? 4. Was the recruitment strategy appropriate to the aims of the research? 5. Was data collected in a way that addressed the research issue? 6. Has the relationship between researcher and participants been adequately considered? 7. Have ethical issues been taken into consideration? 8. Was the data analysis sufficiently rigorous? To answer this question the Cochrane handbook box 21.8.a was consulted (Cochrane, 2021). 9. Is there a clear statement of findings? 10. How valuable is the research?

The CASP checklist (CASP, 2021) was used to ask equivalent questions for quantitative articles (with a modified second question: 2. Is a quantitative methodology appropriate?), while also taking validity, reliability and generalisability into consideration. As both qualitative and quantitative methods were included, the author of this work decided to use a simple system of approved or not approved articles instead of a scoring system. If the answer was NO to any of the previously mentioned questions, the article would be deemed not approved and be excluded. Out of the remaining articles, selections were based on relevance to the study's aim, perceived number and importance of cross references and citations, and attempt at diversification of perspectives.

The included books were chosen with convenience sampling (Appendix 3). Special care was taken in procuring books with good public reception and credibility. This was ensured through searching the internet for books on the topic of food-food flavour pairing, eventually the number of included books was narrowed down to 4. The selected books were found as top search results in several online book retail stores and had overwhelmingly positive reviews. On Amazon (2021), 79% of reviewers had given 5 out of 5 stars for all 4 books. The selected books also appeared with high ratings on discussion forums and in lists of books on food topic websites. The books were considered if they were available at Örebro university library or

Örebro Public Library, although some books were purchased when determined to be crucial to this study.

Data analysis

To get an accurate and replicable view on the topic of flavour pairing, articles were included only after they appeared in systematic searches. To control search results, carefully selected search words were used when generating a search matrix that keeps track of the processed articles (Appendix 1). An overview of the aim, method, data collection and results of selected articles are presented in an article matrix (Appendix 2).

The aim of the study was answered through qualitative analysis. The synthesis method was descriptive and also interpretive, which puts responsibility on the researcher to avoid making evaluations subjective (SBU, 2021). Through prospective reflexivity, subjective bias was safeguarded against. Although the researcher plays an unavoidable part in content analysis, interpretations were made with as little alterations as possible from the source material. The professional chef background of the author is to be viewed as an asset in this case, as relative expert knowledge is detrimental to tailor the material to use by chefs.

An inductive approach was used for data analysis. The background research provided insights for categorizing meaningful entities found in the results. In the scientific articles, meaning bearing sentences have an unequivocal interpretation. As motivations for pairing flavours are clearly stated, the articles contribute with closer inspections of various food pairing ideas. The selection of books on the other hand, do not represent scientific expertise. One of the most common approaches to interpret qualitative data is by employing thematic analysis methods (Bryman, 2011, p. 528). Passages in the selected books were searched for motivating sentences concerning flavour pairings. Recognising where motivations were comparable, inductive themes were developed. The accuracy of the themes was prioritised over correspondence to previous themes, whenever a motivating sentence did not perfectly fit a previously developed theme, a new theme was created just for that sentence. According to Bryman (2011, p. 528), *Framework* is an appropriate method to encode qualitative data. The *Framework* method is a matrix-based method to order and synthesise data. When all meaning-bearing sentences had been accounted for, the total number of meaning-bearing sentences in each theme were compared to get an indication of how prevalent each theme was as a

motivation. In the results, the frequencies of the themes that occurred are presented alongside example sentences coded in the themes.

Ethical considerations

As of the time of writing this study, health and safety regulations recommend limiting physical meetings between people due to an ongoing epidemic. Because of this, the author chose to use a method that did not involve any interpersonal communication. According to Bryman (2011, p. 132), discussion of ethical breaches usually concerns:

1. Harming of participants.
2. Lack of consent.
3. Intrusions of privacy.
4. Fraud, false depictions and hiding important information.

As the information is gathered through books and online sources, the ethical considerations that apply when studying humans directly do not apply. Data collection for this systematic literature review did not involve personal data. For a review, other considerations are of importance, such as transparency and replicability. The systematic procedure of this study has effectively minimized the risk of fraud, false depictions and hiding important information.

Results and discussion

Seven articles and four books provided various approaches to flavour pairing. The articles primarily explore three different approaches to food pairing. The first cultural, the second according to the *Foodpairing* hypothesis, the third computational, which was harder to define but was generally an expansion on the first two. The books consist of a mix of approaches, among them the *Foodpairing* hypothesis, personal experience and intuition, culture, computational gastronomy and recommendations from acclaimed professional chefs. The underlying motivations for choosing to combine ingredients in general seem to be either culture, chemistry or craftsmanship experience and intuition. Although cultural established pairings can be built upon practical reasons such as nutrition, accessibility, economy and chemical reactions, these reasons were not prominent in the sources. Misleadingly, aromatic compatibility is often claimed but at closer inspection overlooked for other sensory qualities

such as texture, sound, visuals, primary taste, pungency or temperature. Applying not only to the other senses but also to smell is the important aspect in culinary craftsmanship of adjusting balance, harmony and complexity.

Aromatic similarity

Researchers seem to disagree on if and how aromatic similarity relates to hedonic valence (Kort et al., 2010., Park et al., 2021). Regardless, it seems to be the most researched approach to flavour combining in recent studies. One way that aromatic similarity could be important to food liking is through food qualities such as harmony, homogeneity and complexity that in themselves hold relative valence. Participants in Eschevins et al. (2018) study were tasked with rating two foods with corresponding beverages that were either of aromatic similarity of contrast, the relative strength of the aroma also differed in the experiment, creating a difference between dominance and balance. For the first food, the aromatically similar pair was perceived as significantly more harmonious, more homogeneous, less complex and significantly preferred (Eschevins et al., 2018). For the second food pairing, in which products were more complex, the balance was not significantly different. However, the aromatically similar pair was perceived as more harmonious and homogeneous in one case, and only different in complexity in another (Eschevins et al., 2018).

As complexity can be seen as a driving objective for flavour pairing as it is linked with positive experiences (Lawless, 2000, p. 92), it can be worth it to consider aromatic similarity when creating recipes. In Eschevins et al. (2018) not yet validated model, there seems to be a sweet spot for complexity, as liking only increases with complexity up to a certain point, whereas liking increases along with harmony monotonically (Eschevins et al., 2018). The principle is thus that a high level of complexity corresponds with predicted high liking only when the level of harmony is also high. According to Eschevins et al. (2018), aromatic similarity modulates pairing properties by increasing harmony and homogeneity and decreasing complexity, although complexity is to be kept a separate property from harmony and homogeneity, as it varies to which extent properties are impacted. Eschevins et al. (2018) offers a possible explanation for how aromatic similarity could be linked with liking, through modulation of perceived properties, that is harmony and complexity. However, this is far from saying that aromatic similarity equals liking.

In the perspective of Coucquyt et al. (2020), who are affiliated with the foodpairing.com website (Foodpairing, 2021), aromatic similarity is the principal motivation for combining food. *The Art & Science of Foodpairing* (Coucquyt et al, 2020, p. 17) states that aromatic similarity affects our experience through four types of interactions between aromas. Synergy, when two aromas create a new or reinforced smell. Inhibition, when aromas are perceived individually and not as blended. Suppression, when the mixture is less intense than the aroma molecule with highest intensity, but more intense than other independent aromas. Overshadowing, when the intensity of the mixture is as high as one of its components but is still overshadowed by another.

The implication is that all flavour pairs in the book are motivated by the *Foodpairing* hypothesis. However, other motivations occasionally play a supporting role.
In addition to aroma wheels and pairing grids that highlight aromatic similarity, the book is filled with 311 descriptive texts out of which 96% had three heading designated by the authors. Potential pairing, meaning novel pairings that are based on aromatic similarity, numbered 155. Classic pairing or classic dish, meaning a traditional or cultural pairing, numbered 127. Chef pairing, meaning the combination was created by a chef, numbered 16. Other motivations also occur, but less frequently, for example when discussing wasabi and chocolate "...the spicy pungent wasabi serving as a striking contrast to the sweet, fatty richness of the chocolate ganache" (Coucquyt, et al, 2020, p. 62). The majority of descriptions alluded to aromatic similarity, for example when recommending pairing pineapple with wild boar, "When you pan-fry or roast wild boar, sugars in the meat caramelize and form new aroma molecules – among them the pineapple furanone. Esters with a pineapple scent form another aromatic link between wild boar and pineapple" (Coucquyt, et al., 2020, p. 242). Representative of a classic pairing recommendation sweet potato with turkey is accompanied by the description "In the southern United States, the Thanksgiving roast turkey is often served with a side dish of oven-roasted sweet potato…" (Coucquyt, et al, 2020, p. 119). To incorporate a professional's view on a flavour pairing the book *The Art and Science of Foodpairing* (Coucquyt, et al, 2020, p. 52) recommends pairing celeriac with Cheddar, "Chef Dan Barber paired celeriac with a Cheddar cheese foam seasoned with white miso…".

The approach of pairing flavours based on aromatic similarity can also be found in other books. *The Flavour Matrix* applies the *Foodpairing* hypothesis through computational

gastronomy (Briscione & Parkhurst, 2018). In addition to flavour matrixes for featured ingredients (flavour wheels with highlighted aromas) and a brief introduction to Briscione & Parkhurst's view on the subject of flavour pairing, the book also offers curated recipes with accompanying descriptions. The motivations behind flavour combinations in the book seem to be solely based on the principle of aroma overlap, with only a few exceptions. For instance, garlic and honey: "The pairing makes sense from a chemical perspective: The strong sulfur aromas of garlic are also prominent in honey" (Briscione & Parkhurst, 2018, p. 21), or lemons and olives: "Olives and citrus have 60 percent of their aromatic compounds in common…" (Briscione & Parkhurst, 2018, p. 181). Although the premise of the book is pairing ingredients by their flavour affinities, texture and taste contrasts appear in supporting roles. In one case, flavour to taste affinity was declared "Cucumbers have a particular affinity for sour flavours, making a tamarind vinaigrette the perfect dressing…" (Briscione & Parkhurst, 2018, p. 93).

According to Briscione & Parkhurst (2018, p. 3), the usual approach to pairing flavours restricts chefs to only using flavour combinations they already know. The ability to recall what goes together based on prior experience Briscione & Parkhurst (2018) calls taste memory. Briscione & Parkhurst (2018) argues that learning just a fraction of the available combinations will take a lifetime, and yet the chef only learns what has been enjoyed in the past and not what could go together. Therefore, we need more effective ways to learn flavour combinations, simply relying on taste memory will not do (Briscione & Parkhurst, 2018). While a computer could make recommendations based on aromatic similarity to assist creativity, it could potentially be programmed to make recommendations based on anything else, equating aromatic similarity with good combinations might become a self-fulfilling prophecy. The creative force of the cook would most likely transform the ingredient pairs into something desirable regardless of the legitimacy of the *Foodpairing* hypothesis (Kort et al., 2010).

The issue with the *Foodpairing* hypothesis is that it makes an unmotivated presumption. Similar flavour profiles are assumed to work better together than dissimilar ones, and better than ingredients alone, but a reason is never given for why they would. As has been shown, harmony has as much to do with contrasts as it has to do with homogeneity (Lawless, 2000).

In Kort et al. (2010) sensory test, the food pairing hypothesis was discredited.

A panel of 50 students were asked to rate pairs of seven ingredients in different configurations on a scale of 1 through 7, where 1 was awful and 7 was very nice. The samples were pre-evaluated to balance flavour intensity. The samples were pureed and had to be consumed blindfolded. Researchers presumed that if aroma compounds were similar between two ingredients to a sufficient degree, then the score for the combined ingredients would be higher than the average score for the separate ingredients, as is suggested by the *Foodpairing* hypothesis. The percentage of common characteristic compounds was not higher for the successful combinations than for the failed combinations, indicating that the *Foodpairing* hypothesis can be rejected (Kort et al., 2010). It is noteworthy that 4 out of 5 of the combinations that were successful included what are arguably sweet dessert ingredients: chocolate and pear. The score for chocolate and pear combinations did not improve when combined compared to the score of the two ingredients on their own. This suggests that other factors such as cultural expectations and taste perhaps had a stronger influence on the students' experience than did aromatic similarity.

The role of flavour in complex food pairing interactions

Giving other factors the opportunity of inclusion, Traynor et al. (2013) was the first to explore food pairing through a holistic approach of organic volatile analysis, hedonic response evaluation and descriptive sensory analysis. The researchers focused on the interactive relationship between perpetual components; they wanted to know why their foods did or did not pair well (Traynor et al., 2013). The food pairings were chosen around banana with the help of the website foodpairing.com (Traynor et al., 2013). Banana was matched with bacon, basmati rice and extra virgin olive oil, combinations that occur in Africa and South America but can be considered novel in a European context. According to the Foodpairing (2021), these foods share key aroma compounds which makes them compatible.

Banana with olive oil was deemed to be an unacceptable pairing, while banana and bacon had the highest percentage as first preference choice, followed by banana and rice in second place (Traynor et al., 2013). Consumers said positive things about the bacon and rice combinations, stating that they worked well together and complemented each other. Conversely, the reception of banana and olive oil was overwhelmingly negative, with the motivation that olive oil aroma and taste overpowered the fruit (Traynor et al., 2013). If the ratio between ingredient amounts was appropriate to ingredient aroma concentration, there are some possible explanations to why the ingredients had a positive or negative effect on the

consumer. It could be that shared aroma compounds in a paired ingredient reinforce inherent qualities that could be either positive or negative. As such, bacon may have added more of the same to what was already pleasant in banana aroma. Whereas, olive oil may have multiplied the unpleasant aromas in banana or made compounds that are only pleasant in low concentrations unpleasant. Another explanation is that banana and olive oil were not perceived as two distinctive aroma notes, but rather an entirely new aroma, a mixture of the two. Researchers conclude that perhaps this new mixture was more reminiscent of something else, another rancid or unpleasant smell (Traynor et al., 2013). In conclusion, the researchers found that pairing novel foods based on aroma compound overlap was lacking as a complete method for food pairing (Traynor et al., 2013). As aroma compounds do not necessarily have synergistic interactions, because they can also be antagonistic, mixture harmony and concentration balance are more important. Indeed, the consumer commentary supports this verdict.

Viewing flavour pairings as unique compositions with their own profile value and not simply an entry on a scale of aromatic similarity might be a more reasonable approach to flavour pairing chemistry. Although cultural novelty was a concern of the researchers, Traynor et al. (2013) did not account for texture and taste qualities of the samples. The relationship between flavour and the five senses are typically understated or ignored in studies concerning flavour pairings (Spence et al., 2015). The same is true for practical and cultural influences on food selection. Food pairing drivers that are not flavour can easily displace the role of flavour in combinations.

A recent study (Kustos et al., 2020) discusses pairing hypotheses in the food-wine pairing field. The balance approach implies that a pairing in which neither component dominates is most liked, and the synergy approach as a drive for ideal matches implies that the whole is more liked than separate elements (Kustos et al., 2020). Although the study does not concern food-food combinations, much like Eschevins et al. (2018), the findings could to some degree be applicable to a situation where the beverage is exchangeable with another food item. A consumer preference test was conducted to find drivers of pairing appropriateness. As consumer liking can be highly dependent on demographic, geographic and behavioural or psychographic measures including gender, neophobia and consumer knowledge, special care was taken in segmenting consumers (Kustos et al., 2020). Consumers across clusters mostly

agreed on the sensory drivers of appropriate pairings, but what was appropriate varied between clusters. In appropriate pairings, flavour intensities as well as complexity increased (Kustos et al., 2020). Unbalanced pairings were favoured over balanced pairings as long as they had positive hedonic valence which indicates that balance alone is a poor predictor of liking (Kustos et al., 2020) In a beef dish pairing, the bolstering of savoury and smoky aromas may have enhanced the perception of bitter taste, decreasing the liking for the pair, indicating that aroma similarity might be a factor, negative in this case but in the case of another beef dish pairing positive, as it may have increased the sense of complexity (Kustos et al., 2020). The researchers suggest that pairings should be judged according to balance, appropriateness, sensory complexity and liking.

The article (Kustos et al., 2020) further highlights how many factors are interwoven in effective flavour combining. The factor of appropriateness was often overlooked in other articles (Eschevins et al., 2018., Kort et al., 2010., Traynor et al., 2013). Computational gastronomy and flavour pairing hypothesis approaches often try to shock the recipe reader with unusual combinations, upon closer examination, the combination is not shocking because it includes clashing aromas, but because it includes sweet dessert ingredients in the same recipe as savoury main course ingredients. Generally sweet dessert foods should not be paired with savoury main or starter course foods (Yeomans et al, 2008). The question the cook should ask himself is therefore: is this combination culturally desirable within the situation? Professional chefs constantly give meaning to food through association.

Artisanal knowledge

In *The Flavor Bible* (Page & Dornenburg, 2008), recommendations are made based on compiled expert chef advice. Karen Page & Andrew Dornenburg have previously written several popular books that concern flavour pairing, but only *The Flavour Bible* was included to avoid data saturation. It was chosen above other options as it is their most critically acclaimed book focusing on flavour combinations from a chef perspective. In the first part of the book, sensory and other vaguer reasons for combining foods are mentioned. Concerning flavour, concepts akin to balance and terroir are mentioned (Page & Dornenburg, 2008, p. 1-33). The book displays recommended pairings in chart form, where flavour affinities are outlined. The flavours are coded by the relative number of times they were mentioned and to what degree of enthusiasm they were recommended by experts. The classification ranges from suggested by one or more experts to most highly recommended by the greatest number of

experts (Page & Dornenburg, 2008, p. 37). Some of the most highly recommended pairings were apple with cinnamon, beans with lamb, chard with garlic, raspberries with white chocolate and rhubarb with strawberries. Experts also agreed that strawberries with pistachios should be avoided and that tarragon should not go with other herbs (Page & Dornenburg, 2008, p. 268,.343)

Scattered throughout the charts are comments by esteemed chefs. These comments do not add up to any overarching principles but rather serve as anecdotes, giving only the occasional glimpse into the chef's motivation. The culinary craft is a creative endeavour where the chefs have been inspired by what they have seen throughout their life. Past experience as shown in quotes like ”I probably have a fondness for it because I associate it with so many childhood flavors…” and “I’m sometimes inspired by looking back to my childhood and the combinations of flavors I liked” are converted through the chef's professional judgement and technique into pleasing dishes (Page & Dornenburg, 2008, p. 62,. 274).

Chefs and recipe creators are fully capable of justifying their flavour choices with non-flavour motivations and will more often than not do so if given the opportunity. In *Exploring Attitudes and Reactions to Unfamiliar Food Pairings: An Examination of the Underlying Motivations and the Impact of Culinary Education* (Traynor et al., 2021), largely the same initial ingredient pairings as Traynor et al. (2013) used were presented in three focus groups, in the form of odours. The pairings were gathered from the website foodpairing.com and were centered around banana. To ensure the novelty of the pairings, two professional chefs, two culinary instructors and a culinary historian were consulted. The 22 participants were ultimately tasked with selecting the two most preferred novel pairings, these were banana with bacon and banana with rice (Traynor et al., 2021). In the second phase of the study 76 panelists were recruited for sensory evaluation of ice creams flavoured with the aforementioned food pairs, a group of them being culinary trained and another not (Traynor et al., 2021). Panelists were tasked with rating the products on a 9 point Likert scale ranging from like extremely do dislike extremely, state if they would be willing to purchase the product or not, and write comments about their opinion of the ice creams which later were analyzed for positive, negative or neutral valence (Traynor et al., 2021). For the focus group, the researchers found that an unfamiliar food pairing can be liked because of its resemblance to familiar food profiles (Traynor et al., 2021). Pairing choices were motivated by disgust and

cultural appropriateness (Traynor et al., 2021). Some odours were not judged as disgusting when they first smelled, but only when the ingredients had been revealed. Conversely, ideational food pairing rejections could be overturned by pleasing attributes of the food itself, along the lines of "it should not taste good but it actually does" (Traynor et al., 2021).

Additionally, the subtheme of cultural relativity ran through the participants' motivations (Traynor et al., 2021). The sensory evaluation test showed that the culinary-educated cohort liked the banana-bacon ice cream significantly more than did the control group. A possible explanation is that the bacon ice cream had a more complex taste, which was reported as interesting by culinary students, but as unusual by the control group (Traynor et al., 2021). We can see again how taste is a matter of perspective. The control group demonstrated negative sensory-affective motivation and ideational motivation, whereas the culinary educated group demonstrated a sensory affective positive reaction, seeming to be more insensitive to ideational motivation. In other words, banana and bacon ice cream was perceived as being both good and bad together, but the control group already had cultural expectations before tasting (Traynor et al., 2021).

Interactions between the senses, flavour motivations as a misnomer and the dominance of culture

A reason for combining flavour that did not appear in the selection of articles but has been treated extensively in the background of this work is the motivation of mistakenly attributing flavour to another perpetual or practical reason (Spence et al., 2015). People will frequently answer questions about flavour combinations with how a food feels or tastes, or feel disgust at the prospect of cultural inappropriateness. This leans into the next motivation, when the reason is not at all perpetual but only cultural. Traditional flavour pairings can in turn be seen as a development of practical flavour pairing, habits formed from where our physiological programming meets varying options of the local environment, the flora and fauna. In culture, the practical reasons for combining food transitions to impractical reasons in a display of group belonging and solidarity. There is then the factor of individual variance, preferences in personal sensory experience that the chef cannot account for if his guest is not interviewed before the meal. Perhaps individual preferences are best thought of as a microcosm of cultural preferences.

The Flavour Thesaurus (Segnit, 2020) is perhaps the most personal and in depth look at flavour combinations available right now. In Segnit's own words the pairings draw upon "flavour science, history, culture, chefs' wisdom and personal prejudice" and "expert opinions" were consulted (Segnit, 2020, p. 8, p. 11). Some principles promoted by the book are using flavours to disguise, bolster, suppress or enliven other flavours, and an idea that rice, pasta, black pepper and vinegar fit with so much that they can virtually be ignored (Segnit, 2020, p. 7, p, 11). The content in the book consists of short general descriptions of single flavours and lists of paired ingredients. These ingredient pairs are accompanied by short texts, often vague but also bearing meaning. After searching these passages for motivational statements and coding them the following themes were found (Table 2).

Table 2.
Distribution of coded sentences concerning pairing motivations in *The Flavour Thesaurus* (Segnit, 2020).

Themes	Number of occurrences
Affective / Nostalgic	47
Cultural (Historic, classic or where it occurs)	213
Chefs and recipe makers	33
Mixing (Boosting, Hiding and Altering properties)	28
Other than aroma (Texture, taste, visuals, temperature, pungency)	66
Aroma similarity	34
Aroma contrast	12
Goes well with something similar	14
Goes well with a third ingredient	5
Terroir	15
Medicinal	1
Aroma-flavour interaction	1

The majority of motivations belonged to the Cultural theme (Table 2). An example of this would be “Gravadlax, probably the most famous, is salmon cured with sugar and salt, flavoured with dill and mustard” under the heading Oily Fish and Dill (Segnit, 2020, p. 157), referring to a traditional Nordic dish. Affective/Nostalgic sentences were also relatively frequent (Table 2), examining food pairings from the perspective or the author's experience and memories. An example of this would be “A last-night-of-the-holiday atmosphere invariably obtains in the Motorail bar, and a late, shared snack is always welcome...” when Prosciutto and celery is mentioned (Segnit, 2020, p. 171). Reasons other than aroma (Texture taste, visuals, heat) were about as frequent as Affective/Nostalgic (Table 2). An example of this would be “I associate black pudding with cold weather and hearty dishes, perky broad beans with bright, summery sweetness. Fresh mint has a foot in both camps" when describing Black Pudding with Mint (Segnit, 2020, p. 39).

There were also the closely related categories of Mixing, Aroma similarity and Aroma contrast, which separately were mentioned relatively few times, but all together were mentioned frequently (Table 2). An example of Mixing would be “Potato bulks out the meal, of course, but also calms the rude flavour” when writing about potato with smoked fish (Segnit, 2020, p. 166). An example of Aroma similarity would be “Capric acid also makes a significant contribution to the flavour of goat’s cheese” when talking about Goat’s Cheese with Caper, or (Shiitake contain a compound called lenthionine chemically similar to the sulphides found in alliums such as garlic” when talking about Mushroom with Garlic (Segnit, 2020, p. 55, p. 77). An example of Aroma contrast would be Prosciutto and asparagus “... release its flavour, providing a heavenly contrast to asparagus’s sulphurous sweetness” (Segnit, 2020, p. 171). In a few examples, terroir was mentioned like this “Add a handful of mushrooms to the pot with your chicken and they will contribute a gamy flavour that makes the bird taste as if it really did come from the woods” when describing pairing chicken with the mushroom called hen-of-the-wood, or “As lamb is often suited to flavours redolent of its habitat - grassy, herbal, maquis - so pork is complemented by the earthy flavour of cumin” (Segnit, 2020, p. 29, p. 35). Occasionally, a famous chef was mentioned in connection to an ingredient pair, or two ingredients were stated as good together because they both worked well with a third (Table 2), “Heston Blumenthal paired white chocolate with ham, anchovies and cured duck before alighting on the particularly pleasing pairing of caviar” and “So it’s perhaps not surprising that apple, which goes so well with rich, delicate blood sausage, should go well with liver too” (Segnit, 2020, p. 153,. 41). The remaining ingredient pair descriptions

were either too meandering or bland to be analysed, or used non-motivations as “they are made for each other” or “they taste good together” (Segnit, 2020). When this was the case the descriptions were not coded.

In an attempt to answer the question of whether there are any permeating food pairing principles that overrides cultural practice and individual preference, Ahn et al. (2011) introduced a flavour network over flavor compounds in culinary ingredients typical for five different cultures. These cultures were broadly defined geographically as North American, Western European, Southern European, Latin American and East Asian. A number of 56,498 recipes were gathered from internet repositories. The average number of ingredients was eight. Some ingredients appeared in as many as over 20,000 recipes, while 16 ingredients appeared only once. This suggests that some ingredients are more favourably combined, while others such as jasmine tea and Jamaican rum (Ahn et al., 2011), are preferably enjoyed alone.

North American and Western European cuisines tended to use ingredient pairs with aromatic similarity in support of the food pairing hypothesis. East Asian and South European cuisines were the opposite, pairing ingredients by aromatic dissimilarity more than was to be expected by chance (Ahn et al., 2011). In this study flavour compound similarity or dissimilarity between two ingredients were correlated with likelihood of use in recipes depending on culture respectively (Ahn et al., 2011). When ingredient frequency was accounted for, this effect dropped below statistical significance. This suggested to the researchers that the *Foodpairing* hypothesis depended on the most popular ingredients. These were milk, butter, cocoa, vanilla, cream and egg in North America, and beef, ginger, pork, cayenne chicken and onion in East Asia (Ahn et al., 2011).

Researchers then analysed their data from the perspective of Rozin’s (2000) flavour principle. They wanted to know if they could systematically identify the key ingredient combinations associated with a culture. The most authentic ingredients for North American cuisine were deemed to be dairy, eggs and wheat. The dominating East Asian ingredients were soy sauce, sesame oil, rice and ginger (Ahn et al., 2011). The six most authentic ingredients for each regional cuisine were compared which showed that Western European cuisine was closely related to North American cuisine, while Southern European cuisine used overlapping ingredient pairing with Latin America, and to a lesser degree East Asia (Table 3). The

occurrence of ingredients by region in *Table 3* is reminiscent of the ingredients that would be expected to be found in the three gastro-geographical belts (Bode, 2000, p. 43).

Table 3.
The six most authentic ingredients for different regions as presented in *Flavor network and the principles of food pairing* (Ahn et al, 2011).

Western European	North American	Southern European	Latin American	East Asian
milk	milk	garlic	garlic	garlic
butter	butter	onion	onion	scallion
vanilla	vanilla	tomato	tomato	sesame oil
egg	egg	olive oil	cayenne	cayenne
wheat	wheat	macaroni	corn	rice
-cream -thyme	cane molasses	-parmesan cheese -basil		- ginger - soybean - soy sauce

The network connects 381 ingredients with 1021 contributing flavour compounds (Ahn et al., 2011). Ingredient pairs were assessed by the number of shared flavour compounds. When links between ingredients were checked for statistical significance, it was found that ingredients shared the most flavour compounds with other ingredients in their food classes, that is to say peaches had the most in common with other fruits (Ahn et al., 2011). Food classes were also shown to differ in flavour compound similarity to each other, with fruits and dairy being closest to alcoholic drinks, meats being closer to seafood and vegetables, and mushrooms being isolated from the rest (Ahn et al., 2011).

Perhaps it is unlikely that a successful system for creating novel flavour combinations can ever be produced. A food pairing hypothesis built on foundations of chemistry is useful only when it is validated on human subjects. Food can not be isolated from the human experience. Using artificial intelligence to learn about previous human food experiences and build conclusions upon them makes for a more accurate system than simply matching aroma compound similarity, since it is culture dependent.

In a recent study, Park et al. (2021) attempted to improve upon the flavor network project of Ahn et al. (2011) by including more recipes and ingredients and using meta paths between them. The FlavorGraph unites the *Foodpairing* hypothesis with ingredient co-occurrence frequency in 1 million recipes (Park et al., 2021). The new network connects 6653 ingredients and 1561 food-related chemical compounds (Park et al., 2021). Out of the 6653 ingredient nodes, only 416 ingredients had known chemical information, this caused the researchers to split the ingredients into two groups accordingly (Park et al., 2021). The ingredients with no chemical information were incorporated into the system by indirectly linking them with flavour compounds through their connection to the 416 ingredients with known chemical information. In addition to measuring shared aroma compounds, the statistical co-occurrence of flavour pairs was also incorporated into the system (Park et al., 2021). A number of 1 million recipes were included.

Much like in *The Flavor Network* (Ahn et al., 2011), this study showed that foods in the same food class were on average chemically more similar than foods from different classes were (Park et al., 2021). However, pairings between chemically similar ingredients did not outdo chemically dissimilar ingredient pairs when checked for frequency of co-occurrence in recipes. Park et al. (2021) views flavour compound information as fundamental to food pairing.

Bringing knowledge together for a multidisciplinary approach

Going forward, there are two possibilities for flavour pairing science, either aroma pairing is to be viewed as entirely a cultural/intellectual endeavor, or a mix of cultural and perpetual. Meals are a way for people to show group belonging, by choosing what and how they eat (Outram, 2007, p. 60). Aromatic similarity does not rival culture in predicting liked combinations. Yet, flavour pairing has already been confirmed to be reliant on aroma compound similarity, but only in the sense that similarity can narrow down and focus flavours, and dissimilarity can broaden and make flavours complex. To equate this single aspect of flavour to what makes a good pairing is only considered because of specific cultural examples. The maturing approach to incorporating aroma compound information is to view pairs as synergistic or antagonistic mixes of molecules, in other words, do key molecules form a smell image that is pleasurable? If the central objective of flavour pairing is accepted to be synergy as Harrington proposes (2005), then aromatic volatiles may have to be considered to achieve harmony.

It is tempting to look for an ultimate physiological solution, but to make such a claim, scientists would have to somehow prove that there is a physiological basis for liking flavour combinations in an experiment that omits the possibility of cultural influence. As have been shown by Yeomans et al. (2008), the presence of soft taboos creates expectations that relate to the classical menu structure. As of now the research supports that the only meaning of combining flavour entities is cultural, in other words, there are no flavour combinations until the flavour combinations are processed through the cultural machinery. This idea might seem controversial, as most of us can with absolute certainty say that we have experienced flavour combinations that did work and others that did not. But in fact, there seems to be no way to tell if we have motivations that are not cultural/intellectual. Maybe without culture, there is no motivation for combining specific flavours.

Method discussion

A systematic literature review was chosen as the method for this study, as flavour pairing rationale is not common knowledge, and would if anywhere be found in literature. A quantitative method would most likely not have been more effective than this study's qualitative method in generating a comprehensive overview and new insights. This is because the focus of research questions in articles and design of books on the topic of flavour pairing are too diverse to make a direct comparison. The choice to include books as well as articles gave added value to the analysis, as a more complete picture of the available knowledge could be presented.

A perspective that is arguably still underrepresented despite my best efforts is the chef's perspective. Culinary knowledge often equals silent knowledge, that is, chefs often have expert knowledge that they cannot fully articulate. If interviews with chefs would have been chosen as a method for this study, then this would likely be an issue. Moreover, attempts to document chef knowledge is relatively rare and what has been gathered often consists of uncollected thoughts that are too anecdotal to be of use. If a review could be made that only includes the chef perspective, the results could be different. That being said, a strength of this study is that the breadth of factors that were included makes the results generalisable. In this study's findings, chefs as well as recipe creators seem to be motivated in largely the same way as people in general.

In a systematic review, the influence of the author's own prejudice is minimized by using systematic and transparent procedure (Bryman, 2011, p, 102). In a systematic review, it is necessary to describe the author's background (SBU, 2021). I obtained a bachelor's degree from the program Chef – Culinary Arts and Meal Science at Örebro University in the year 2019 and have since continued studying food. I have worked professionally as a chef since 2017. Qualitative studies are often criticised for being subjective (Bryman, 2011, p. 368), and the degree to which subjectivity can be considered prevalent in this study should also be taken into account. While a strength of this study is its transparency and replicability, the discussion and interpretation of the data relies on a single person. It is likely that a researcher following the study's procedure would attain largely the same data, but the interpretation of that data would likely differ slightly. For better or worse, the value of this study is determined by my ability to understand and in turn mediate to others in a way that makes sense the topic of flavour combinations.

The available resources for conducting this study were limited. As such the literature that has been included is also limited. This could be seen as a threat to the scientific value of this project and the question needs to be asked, was the right literature chosen? A couple of books were not included because of being written before 1995 and also being unavailable for loan or purchase at the time of writing but would most likely have made an impactful contribution to the results. The books Ethnic cuisine: How to Create the Authentic Flavors of Over 30 International Cuisines (Rozin, 1992), and The Flavour-Principle Cookbook (Rozin, 1973) seems to have inspired many of the researchers and authors both in the background and the results of this study. The loss of the influence these books would have had are partly mitigated by Rozin's ideas being included in *The Role of Flavour in the Meal and in the Culture* (Rozin, 2000), and indirectly by other authors. As not all titles that appeared in the search results were read, there is a possibility that important works were missed. However, a sufficient number of titles were read, when considering the scope of this project and the time and resources at hand, as such it is not customary to read everything. As the search results were sorted according to relevance, reading more titles would have yielded diminishing returns.

Conclusions

If tradition is the basis of food liking, then perhaps there is a roof for what can be achieved culinary. The comment "the best I have ever eaten", cannot stray too far from what has already been culturally established. If instinct is the basis of liking, then there are ideals built into the world that can be discovered and strived towards. As usual, the truth probably lies somewhere in between. When aromatic similarity was brought up in the flavour pairing books, criticism was absent. Conversely, the value of aromatic similarity was disputed in the articles. Even when the *Foodpairing* hypothesis was supported, its use was deemed to be limited. Cultural reasons for pairing flavours appeared as factors in the articles as well as the books (Appendix 3).

The literature reviewed in this study supports the view that culture is the most dominant influence on flavour pairing. Practical reasons to pair flavours such as nutrition, accessibility, economy and chemical interactions are inevitable parts of our daily lives but seem to be rarely discussed separately from culture. For flavour pairing appropriateness, context is key, as culture places soft taboos for in what situation flavours should and should not be consumed. There seems to be support for harmony systems and theories for how flavour interactions influence complexity and other valuable food characteristics. Food pairing motivations are often misattributed to flavour when other perceptual stimuli are at work.

In accordance with the criticism raised against the *Foodpairing* hypothesis (De Keppler, 2011), it should be noted that aroma compound overlap has not been proven to be preferred over asymmetrical ingredient pairs (Kort et al, 2010). However, this does not mean that the flavour theory is not useful as a tool. Mapping of ingredient aroma compounds and their connection to similar ingredient flavour profiles brings into awareness the inner workings of the flavour experience. As a tool, the theory highlights an important aspect – albeit not an aspect supreme to the point of exclusion of all other factors, of combining flavours. While the claim that the alignment of aroma compounds results in good matches can be disputed, it is undeniable that similarity can be perceived and is one of the primary variables in the aroma subcategory of the art of food pairing.

Perhaps a scientific approach to systematic flavour combining will remain forever out of reach, or perhaps it is just more complicated than what was initially thought. If no other connection between aromas than compound similarity can be found, perhaps each pairing

should be considered unique. Could the combined experience of consumers and professionals be used to create a flavour pairing system that combines human experience and chemistry? The phenomena of flavour has its roots in physiological chemistry and is experienced subjectively under the influence of cultural habits. Its study lies in the intersection between two vastly different worlds. One highly measurable but overwhelmingly complex, one easy to conceptualise but unthinkable to outline.

The other extreme is that flavours may not have any intrinsic affinity for one another other than those we create by association. Do juniper berries and chanterelle mix well with wild game because of their hedonic value due to a particularly pleasurable chemical blend that hits the back of the throat, or do they belong together as ingredients because we associate them all with the forest? Without the food creator knowing it, flavour combinations become chosen not for the flavour, but rather everything else.

Practical usage and future research

The results of this study builds a foundation for further research into the motivation behind flavour combinations. It provides an overview for anyone looking for an introduction into the subject of flavour combining. The information presented here offers insight into possible explanations for complex questions and could serve as an inspiration for generating new research ideas.

A takeaway from this study is that cultural appropriateness restricts novel flavour combinations and is the dominating influence on flavour motivations overall. Soft taboos make ingredients appropriate only in certain contexts, this could be a certain spot in the menu order, such as dessert, or only during a holiday season. There are different flavour principles depending on regionality, but aromatic similarity seems to be a factor only in a western context. Aromatic similarity is useful for modulating aroma intensity and balance. A final takeaway is that flavour compatibility is often mistakenly motivated by other sensory inputs and not aroma. When chefs become aware of the motivations for flavour pairing, they can choose between them when creating recipes. If chefs have a language for flavour pairing motivations, they can work in a systematic way and eliminate the use of pairings with questionable reasoning behind them,

Flavour principles can be used for cultural dishes, aromatic similarity can be used to modulate contrasts, balance and complexity. In developing new systems and theories for combining flavours and conducting future research a multidisciplinary approach is necessary that takes these factors into account. More research is needed to understand the impact culture has on liking flavour combinations, the role of flavour in the larger context of food pairing as a whole, particularly in food-food combinations.

References

Ahn, Y. -Y., Ahnert, S., Bagrow, J., & Barabási, A. -L. (2011). Flavor network and the principles of food pairing. *Scientific Reports*, Volume 1, Issue 1, Article number 196.

Albala, K. (2003). *Food in early modern Europe.* USA: Greenwood publishing group Inc.

Alcock, J. (2006). *Food in the ancient world.* USA: Greenwood publishing group Inc.

Amazon. (2021-06-03). *Amazon*. https://www.amazon.se/ref=nav_logo

Bode, W. K. H. (2000). *European Gastronomy: The Story of Man's Food and Eating Customs.* London: Grub Street.

Briscione, J., & Parkhurst, B. (2018). *The Flavour Matrix: The art and science of pairing common ingredients to create extraordinary dishes*. New York: Houghton Mifflin Harcourt Publishing Company.

Bryman, A. (2011). *Samhällsvetenskapliga metoder*. Stockholm: Liber AB.

CASP (2021-06-03). *CASP, Qualitative Checklist 2018*. https://www.google.com/url?q=https://casp-uk.net/wp-content/uploads/2018/01/CASP-Qualitative-Checklist-2018.pdf&sa=D&source=editors&ust=1622714886692000&usg=AOvVaw1hmQX8thUVXoSTT1qJ5mO5

Cochrane. (2021-06-03). *Cochrane Training Handbook, Chapter 21: Qualitative evidence*. https://training.cochrane.org/handbook/current/chapter-21#section-21-8

Colgate. (2021-06-03). *Orange Juice and Toothpaste: Why They Don't Mix*. https://www.colgate.com/en-us/oral-health/brushing-and-flossing/orange-juice-and-toothpaste-why-they-dont-mix

Coucquyt, P., Lahousse, B., & Langenbick, J. (2020). *The Art & Science of Foodpairing: 10,000 flavour matches that will transform the way you eat*. London: Octopus Publishing Group Ltd.

De Keppler, M. (2011). Food Pairing Theory: A European Fad. *Gastronomica*, Volume 11, Issue 4, Pages 55-58.

Eschevins, A., Giboreau, A., Allard, T., & Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference*, Volume 65, Pages 18-27.

Foodpairing. (2021-06-03). *Foodpairing*.
https://www.foodpairing.com/en/home

Galmarini, MV. (2020). The role of sensory science in the evaluation of food pairing. *Current Opinion in Food Science*, Volume 33, Pages 149-155.

Grimm, V. (2007). Tasters of Ancient Greece and Rome. In Freedman, P. (Eds.), *Food: The history of taste* (p. 63-98). London: Thames & Hudson Ltd.

Gustafsson, I. -B., Öström, Å., Johansson, J., & Mossberg, L. (2006). The Five Aspects Meal Model: a tool for developing meal services in restaurants. *Journal of Foodservice*, Volume 17, Issue 2, Pages 84-93.

Harrington, R. (2005). The Wine and Food Pairing Process. *Journal of Culinary Science & Technology*, Volume 4, Issue 1, Pages 101-112.

Kort, M., Nijssen, B., van Ingen-visscher, K., & Donders, J. (2010). Food pairing from the perspective of the 'volatile compounds in food' database. In Blank, I., Wüst, M., & Yeretzian, C. (Eds.), *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium*. Winterthur: Institute of Chemistry and Biological Chemistry.

Kustos, M., Heymann, H., Jeffery, D., Goodman, S., & Bastian, S. (2020). Intertwined: What makes food and wine pairings appropriate?. *Food Research International*, Volume 136, Article 109463.

Lawless, H. (2000). Sensory Combinations in the Meal. In Meiselman, H. (Eds.), *Dimensions of the Meal: The science, culture, business and art of eating* (p. 92-104). Gaithersburg: Aspen Publishers Inc.

Livsmedelsverket. (2021-06-03). *Näringsrekommendationer*.
https://www.livsmedelsverket.se/matvanor-halsa--miljo/kostrad/naringsrekommendationer

Lizarondo, L., Stern, C., Carrier, J., Godfrey, C., Rieger, K., Salmond, S., Apostolo, J., Kirkpatrick, P., & Loveday, H. (2020). Chapter 8: Mixed methods systematic reviews. In Aromataris, E., & Munn, Z. (Eds.), *JBI Manual for Evidence Synthesis*. Available from: https://synthesismanual.jbi.global

McGee, H. (2020). *Nose Dive: a field guide to the world's smells.* London: John Murray.

Nygren, T., Nilsen, A., & Öström, Å. (2017). Dynamic changes of taste experiences in wine and cheese combinations. *Journal of Wine Research*, Volume 28, Issue 2, Pages 105-122.

Outram, A. (2007). The Evolution of Taste in Prehistory. In Freedman, P. (Eds.), *Food: The history of taste* (p. 35-62). London: Thames & Hudson Ltd.

Page, K., & Dornenburg, A. (2008). *The flavor bible: the essential guide to culinary creativity, based on the wisdom of America's most imaginative chefs*. New York: Little, Brown and Company.

Park, D., Kim, K., Kim, S., Spranger, M., & Kang, J. (2021). FlavorGraph: a large-scale food-chemical graph for generating food representations and recommending food pairings. *Scientific Reports*, Volume 11, Issue 1, Article 931.

Paulsen, M., Rognså, G., & Hersleth, M. (2015). Consumer perception of food-beverage pairings: The influence of unity in variety and balance. *International Journal of Gastronomy and Food Science*, Volume 2, Issue 2, Pages 83-92.

Prescott, J., & Monteleone, E. (2015). Consumer perceptions of food and beverage flavour. In Parker, J. K., Elmore, J. S., & Methven, L. (Eds.). *Flavour Development, Analysis and Perception in Food and Beverages* (p. 369-382). Cambridge: Woodhead Publishing.

Prescott, J. (2012). *Taste Matters: Why We Like the Foods We do.* London: Reaktion Books Ltd.

Rozin, E. (2000). The Role of Flavour in the Meal and the Culture. In Meiselman, H. (Eds.), *Dimensions of the Meal: The science, culture, business and art of eating* (p. 134-142). Gaithersburg: Aspen Publishers Inc.

Rozin, E. (1992). *Ethnic Cuisine: How to Create the Authentic Flavors of Over 30 International Cuisines*. London: Penguin Books.

Rozin, E. (1973). *The Flavor-Principle Cookbook*. England: Hawthorn Books.

SBU. (2021-06-03). *Statens beredning för medicinsk och social utvärdering, metodbok*. https://www.sbu.se/sv/metod/sbus-metodbok/?pub=48286

Schafheitle, J. M. (2000). Meal Design: A Dialogue with Four Acclaimed Chefs. In Meiselman, H. (Eds.), *Dimensions of the Meal: The science, culture, business and art of eating* (p. 270-308). Gaithersburg: Aspen Publishers Inc.

Scholliers, P. (2007). The New Landscape for Gastronomy. In Freedman, P. (Eds.), *Food: The history of taste* (p. 333-357). London: Thames & Hudson Ltd.

Segnit, N. (2020). *The Flavour Thesaurus: Pairings, recipes and ideas for the creative cook*. London: Bloomsbury Publishing.

Shepherd, G. (2013). *Neurogastronomy: how the brain creates flavour and why it matters.* New York: Columbia University Press.

Spence, C., Auvray, M., & Smith, B. (2015). Confusing Tastes with Flavours. In Stokes, D., Matthen, M., & Briggs, S. (Eds.). *Perception and Its Modalities* (p. 246-274). Oxford: Oxford University Press.

Traynor, M., Moreo, A., Cain, L., Burke, R., & Barry-Ryan, C. (2021). Exploring Attitudes and Reactions to Unfamiliar Food Pairings: An Examination of the Underlying Motivations and the Impact of Culinary Education. *Journal of Culinary Science & Technology*, Volume 19, Issue 2, Pages 115-137.

Traynor, M., Burke, R., O'Sullivan, M., Hannon, J., & Barry-Ryan, C. (2013). Sensory and chemical interactions of food pairings (basmati rice, bacon and extra virgin olive oil) with banana. *Food Research International*, Volume 54, Issue 1, Pages 569-577.

Ulrichsweb. (2021-06-03). *Ulrichsweb global serials directory*. https://ulrichsweb-serialssolutions-com.db.ub.oru.se/

Wilkins, J., & Hill, S. (2006). *Food in the Ancient World.* New Jersey: Blackwell Publishing Ltd.

Wrangham, R. (2015). Flavour in the context of ancestral human diets. *Frontiers in integrative neuroscience*, Volume 9. Conference Abstract: Science of Human Flavor Perception. https://doi.org/10.3389/conf.fnint.2015.03.00009.

Yeomans, M., Chambers, L., Blumenthal, H., & Blake, A. (2008). The role of expectancy in sensory and hedonic evaluation: The case of smoked salmon ice-cream. *Food Quality and Preference*, Volume 19, Issue 6, Pages 565-573.

Appendix 1

Search matrix

Web of science

Search settings:

Search 1: You searched for: TOPIC: (flavo$r*) *OR* TOPIC: (taste*) *OR* TOPIC: (aroma*) *OR* TOPIC: (food*) *AND* TOPIC: (pairing*) *AND* TOPIC: (combination*) *AND* TOPIC: (pair*)
Refined by: WEB OF SCIENCE CATEGORIES: (FOOD SCIENCE TECHNOLOGY) AND DOCUMENT TYPES: (ARTICLE) AND RESEARCH AREAS: (FOOD SCIENCE TECHNOLOGY) AND LANGUAGES: (ENGLISH)
Timespan: 1995-2021. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Search 2: You searched for: TOPIC: (flavo$r*) OR TOPIC: (aroma*) OR TOPIC: (food*) OR TOPIC: (odour*) OR TOPIC: (ingredient*) NOT TITLE: (taste*) NOT TOPIC: (beverage*) NOT TOPIC: (wine*) NOT TOPIC: (beer*) NOT TOPIC: (coffee*) NOT TOPIC: (tea*) AND TOPIC: (combination*) AND TOPIC: (pairing*) AND TOPIC: (match*) AND TOPIC: (harmony) AND TOPIC: (pair*) AND TOPIC: (computational) AND TOPIC: (computational gastronomy) AND TOPIC: (artificial intelligence) AND TOPIC: (computer)
Refined by: WEB OF SCIENCE CATEGORIES: (FOOD SCIENCE TECHNOLOGY OR COMPUTER SCIENCE INTERDISCIPLINARY APPLICATIONS) AND LANGUAGES: (ENGLISH) AND DOCUMENT TYPES: (ARTICLE)
Timespan: 1995-2021. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Search 3: You searched for: TOPIC: (food*) *AND* TOPIC: (pairing*) *AND* TOPIC: (motivation*) Refined by: DOCUMENT TYPES: (ARTICLE)
Timespan: 1995-2021. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Table 4.

Web of Science search matrix.

Search	Total number of articles	Titles read	Abstract read	Articles read	Quality control	Included articles
Search 1	40,122	1500	42	15	2	2
Search 2	151,216	100	0	0	0	0
Search 3	64	64	3	1	1	1

Scopus

Search settings:

Search 1: (TITLE-ABS-KEY (*flavo$r**) OR TITLE-ABS-KEY (*aroma**) OR TITLE-ABS-KEY (*odour**) OR TITLE-ABS-KEY (*food**) OR TITLE-ABS-KEY (*ingredient**) AND TITLE-ABS-KEY (*combination**) AND TITLE-ABS-KEY (*pair**) AND TITLE-ABS-KEY (*pairing**) OR TITLE-ABS-KEY (*taste**)) AND (LIMIT-TO (DOCTYPE , *"ar"*)) AND (LIMIT-TO (LANGUAGE , *"English"*)) AND (EXCLUDE (SUBJAREA , *"CENG"*) OR EXCLUDE (SUBJAREA , *"MEDI"*) OR EXCLUDE (SUBJAREA , *"PHAR"*) OR EXCLUDE (SUBJAREA , *"ENVI"*) OR EXCLUDE (SUBJAREA , *"IMMU"*)) AND (EXCLUDE (SUBJAREA , *"NURS"*) OR EXCLUDE (SUBJAREA , *"PHYS"*) OR EXCLUDE (SUBJAREA , *"VETE"*) OR EXCLUDE (SUBJAREA , *"ENGI"*) OR EXCLUDE (SUBJAREA , *"MATH"*) OR EXCLUDE (SUBJAREA , *"EART"*) OR EXCLUDE (SUBJAREA , *"ENER"*))

Search 2: (TITLE-ABS-KEY (*flavour**) OR TITLE-ABS-KEY (*flavor**) OR TITLE-ABS-KEY (*aroma**) OR TITLE-ABS-KEY (*food**) AND TITLE-ABS-KEY (*pairing**) AND TITLE-ABS-KEY (*computational* AND *gastronomy*) OR TITLE-ABS-KEY (*artificial* AND *intelligence*)) AND (LIMIT-TO (LANGUAGE , *"English"*))

Table 5. Scopus search matrix.

Search	Total number of titles	Titles read	Abstracts read	Articles read	Quality control	Included articles
Search 1	119	119	5	4	1	1
Search 2	4	4	4	3	0	0

Google Scholar

Search settings:

Search 1:

(flavor*)+OR+(flavour*)+OR+(aroma*)+OR+(odour*)+OR+(taste*)+OR+(food*)+OR+(ingredient*)+AND+(pairing*)+AND+(combination*)+AND+(pair*)+AND+(food-food)*

Search 2: food*+AND+pairing*

Table 6. Google Scholar search matrix.

Search	Total number of articles	Titles read	Abstracts read	Articles read	Quality control	Included articles
Search 1	6850	100	11	8	1	0
Search 2	229000	100	12	5	2	2

Primo

Search settings: Valfritt fält innehåller: flavour* ELLER flavor* ELLER aroma* ELLER food* ELLER taste* OCH pairing* OCH combination*. Filter: Peer-review, Onlineresurser, Artiklar, 1995-2021, Engelska.

Table 7. Primo search matrix.

Search	Total number of articles	Titles read	Abstracts read	Articles read	Quality control	Included articles
Search 1	4156282	100	6	6	1	1

Appendix 2

Article matrix

Table 8. Article matrix.

Author, Title, Publication, Country, Year	Aim	Data collection	Method	Results	Quality
Ahn, Y. -Y., Ahnert, S., Bagrow, J., & Barabási, A. -L. *Flavor network and the principles of food pairing*. Scientific Report Volume 1, Issue 1, Article number 196. The United States of America. 2011.	To test the hypothesis that the choice of ingredients is driven by an appreciation for ingredient pairs that share flavor compounds and develop a flavour network based on flavour principles and aromatic similarity.	A number of 56,498 recipes were gathered from internet repositories.	Quantitative analysis. Researchers measured the mean number of shared compounds, the contribution of each ingredient to the shared compound effect in a given cuisine and authenticity by defining the prevalence of each ingredient in a cuisine.	Some ingredients appeared in as many as over 20,000 recipes, while 16 ingredients appeared only once. This suggests that some ingredients are favourably combined. Aromatic similarity is drive in western society but not in an eastern context.	Approved
Eschevins, A., Giboreau, A., Allard, T., & Dacremont, C. *The role of aromatic similarity in food and beverage pairing*. Food Quality and Preference, Volume 65,	To investigate how aromatic similarity modulates consumers' judgment of pairings.	Pairings were assessed by a group of 47 participants, 29 of them women and 18 men, between the ages of 20 and 55.	Quantitative. Aromatised beverages were paired with verrines and dairy products. Participants assessed pairings in terms of liking harmony, homogeneity, complexity, intensity balance and familiarity.	Aromatic similarity between food and beverage promotes good match. Aromatic similarity increases harmony and homogeneity and decreases complexity. The modulation of harmony and complexity also drives liking of the pair.	Approved

Pages 18-27. France. 2018.					
Kort, M., Nijssen, B., van Ingen-visscher, K., & Donders, J. *Food pairing from the perspective of the 'volatile compounds in food' database*. In Blank, I., Wüst, M., & Yeretzian, C. (Eds.), *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium.* Winterthur: Institute of Chemistry and Biological Chemistry. The Netherlands. 2010.	To test whether Foodpairing hypothesis is a valid predictor of good flavour combinations.	A panel of 50 students.	Quantitative. The database 'Volatile compounds in food' was used to select aromatically similar flavour pairs. Seven different ingredients were assessed in all combinations in a sensory test. When the liking score for two combined ingredients were higher than the average score for two separate ingredients the combination was deemed successful.	Results were not in support of the Foodpairing hypothesis. The percentage of common characteristic compounds was not higher for the successful combinations than for the failed combinations, indicating that the Foodpairing hypothesis can be rejected.	Approved
Kustos, M., Heymann, H., Jeffery, D., Goodman, S., & Bastian, S.	To identify sensory attributes of appropriate food and wine pairings and relate them to balance, consumer liking, sensory complexity and	For sensory analysis, a panel of seven sensory assessors were trained, three female and four male. The consumer preference test involved 108	Quantitative. A descriptive analysis panel evaluated four wines paired with four dishes in a total of 16 combinations. Six of the combinations	Appropriate pairings positively correlated with liking sensory complexity and expected price to pay, and negatively with balance as slight	Approved

Intertwined: What makes food and wine pairings appropriate? Food Research International, Volume 136, 109463. Australia / The United States of America. 2020.	expected price.	Americans.	were used in a consumer preference test where consumers were segmented based on demographic factors.	wine dominance was preferred. The quality of food and wine pairings might be better measured with a combination of direct and indirect methods instead of a single scale.	
Park, D., Kim, K., Kim, S., Spranger, M., & Kang, J. *FlavorGraph: a large-scale food-chemical graph for generating food representations and recommending food pairings*. Scientific Report, Volume 11, Article 931. South Korea. 2021.	To compile data from food recipes and chemical information into a large-scale food-compound network graph.	A number of 1 million recipes were included. The network connects 6653 ingredients with 1561 food-related chemical compounds.	Quantitative experiments and qualitative analysis. Chemical and statistical relations between ingredients and compounds were analysed. Data was embedded into a graph the researchers developed to get an overview over food clusterings.	A food-compound network was developed. Chemical relationships between food groups were found and outlined. Ingredients within the same category tend to be chemically similar but high chemical do not necessarily mean good pairings as pairings can be either congruent or complementary.	Approved
Traynor, M., Burke, R., O'Sullivan, M., Hannon, J., & Barry-Ryan, C. *Sensory and chemical interactions of food pairings*	To investigate food pairings as an important sensory phenomenon in order to determine how different components in the selected food pairings affect	A number of 85 untrained panelists.	Quantitative and qualitative. Food pairings with aromatic overlap were examined with organic volatile analysis, hedonic response evaluation and descriptive sensory analysis.	Banana and bacon were the most liked pairing followed by banana and rice. Balancing flavour intensities is an important aspect of flavour pairing. Synergistic and	Approved

(basmati rice, bacon and extra virgin olive oil) with banana. Food Research International, Volume 54, Issue 1, Pages 569-577 Ireland. 2013.	and interact with other components.			antagonistic interactions between the volatile compounds in food can influence the hedonic ratings of food pairings.	
Traynor, M., Moreo, A., Cain, L., Burke, R., & Barry-Ryan, C. *Exploring Attitudes and Reactions to Unfamiliar Food Pairings: An Examination of the Underlying Motivations and the Impact of Culinary Education*. Journal of Culinary Science & Technology, Volume 19, Issue 2, Pages 115-137. Ireland. 2021.	To investigate consumer attitudes and behaviours toward novel food pairings and the impact of culinary education.	Three focus groups with a total of 22 Irish participants over the age of 18. Sensory evaluation panelists with (66 panelists) and without (57 panelists) culinary education.	Mixed methodology, quantitative sensory evaluation and qualitative focus group interviews. Focus group participants were tasked with smelling concealed odour and discussing them. Panelists for sensory evaluation were tasked with assessing two novel ice-cream flavour pairs.	Sensory-affective and ideational factors appeared as underlying motivational factors for hedonic reactions in the study. Consumers with culinary education might have a preference for higher sensory complexity and be more open to to experience novel flavour pairs.	Approved

Appendix 3

List of chosen articles and books

Articles

Ahn, Y. -Y., Ahnert, S., Bagrow, J., & Barabási, A. -L. (2011). Flavor network and the principles of food pairing. *Scientific Reports*, Volume 1, Issue 1, Article number 196.

Eschevins, A., Giboreau, A., Allard, T., & Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference*, Volume 65, Pages 18-27.

Kort, M., Nijssen, B., van Ingen-visscher, K., & Donders, J. (2010). Food pairing from the perspective of the 'volatile compounds in food' database. In Blank, I., Wüst, M., & Yeretzian, C. (Eds.), *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium*. Winterthur: Institute of Chemistry and Biological Chemistry.

Kustos, M., Heymann, H., Jeffery, D., Goodman, S., & Bastian, S. (2020). Intertwined: What makes food and wine pairings appropriate?. *Food Research International*, Volume 136, Article 109463.

Park, D., Kim, K., Kim, S., Spranger, M., & Kang, J. (2021). FlavorGraph: a large-scale food-chemical graph for generating food representations and recommending food pairings. *Scientific Reports*, Volume 11, Article 931.

Traynor, M., Burke, R., O'Sullivan, M., Hannon, J., & Barry-Ryan, C. (2013). Sensory and chemical interactions of food pairings (basmati rice, bacon and extra virgin olive oil) with banana. *Food Research International*, Volume 54, Issue 1, Pages 569-577.

Traynor, M., Moreo, A., Cain, L., Burke, R., & Barry-Ryan, C. (2021). Exploring Attitudes and Reactions to Unfamiliar Food Pairings: An Examination of the Underlying Motivations and the Impact of Culinary Education. *Journal of Culinary Science & Technology*, Volume 19, Issue 2, Pages 115-137.

Books

Briscione, J., & Parkhurst, B. (2018). *The Flavour Matrix: The art and science of pairing common ingredients to create extraordinary dishes*. New York: Houghton Mifflin Harcourt Publishing Company.

Coucquyt, P., Lahousse, B., & Langenbick, J. (2020). *The Art & Science of Foodpairing: 10,000 flavour matches that will transform the way you eat*. London: Octopus Publishing Group Ltd.

Page, K., & Dornenburg, A. (2008). *The flavor bible: the essential guide to culinary creativity, based on the wisdom of America's most imaginative chefs*. New York: Little, Brown and Company.

Segnit, N. (2020). *The Flavour Thesaurus: Pairings, recipes and ideas for the creative cook*. London: Bloomsbury Publishing.