Lemon Cheesecake

Molecular Gastronomy

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Introduction

Molecular gastronomy is a food science discipline in which seeks to investigate the amalgamation of the physical and chemical transformations of food as a result of culinary practices such as spherification. The modern style of cooking involves exploring social, artistic and technical applications of food. Note by note cooking is an aspect of molecular gastronomy which exclusively uses pure compounds. Plant or animal tissues are not used in note by note cooking. Instead dishes are prepared using pure compounds in order to recreate a desired consistency, taste, aroma, appearance or trigeminal sensation. Pure compounds consist of only one type of molecule for example, water, H_2O. Although it is made up of different elements, hydrogen and oxygen, that are bonded together, it only contains one molecule *(Solution: what is a pure compound, 2007).* The concept originated from Hervé This; a French physical chemist who showed great interest in the science behind culinary techniques. He began his work focusing on the mechanisms of the transformations which occur throughout the process of cooking. He is now one of the global leaders in molecular gastronomy. Alongside Hervé, Pierre Gagnaire served the first Note by Note dish produced in a restaurant, this occurred in the Mandarin Oriental in Hong Kong on the 24th of April 2009. *(This, 2015*)

Since then the unique method of preparing food has increased in popularity. The future of note by note cooking is being explored as a method to meet the ever-growing food requirements for the increasing population. According to *(The UN Department of Economic and Social Affairs 2019),* the world's population is expected to reach 9.7billion in 2050, an increase of 2 billion people. The method of note by note cooking can potentially offer enough food to the growing population by reducing spoilage. As noted by *(Hammond et al., 2015)* as much as 40% of food waste intended for human consumption resides in landfill. The use of compounds to reproduce food can reduce excess waste. Compounds can be extracted at the source of production and then fabricated into a food product after transportation, thus eliminating the risk of food spoilage during this process. It seems the future of note by note cooking is limitless, this conclusion arose as the variety of compounds which can be used are endless, one example is pectin.

Pectin is a block polysaccharide which is a component of all plant cell walls, it is most concentrated in citrus fruits and apples. The complex mixture of polysaccharides are heavily branched, largely methyl-esterified blocks that alternate with unbranched blocks of varying degree of esterification. Pectin provides a variety of culinary uses; it is often used for a stabiliser, thickener or gelling agent, citrus pectin and beet pectin also have emulsifying properties. They can reduce the interfacial tension between an oil phase and a water phase

resulting in emulsifying properties. Furthermore, the gelling process is aided by the unbranched, non-esterified blocks which aggregate through calcium binding forming a gel. These properties are often used to produce a firm elastic texture. As suggested by (*Jarvis 1984)*, pectin is potentially cross-linked by diferulate esters when the growth of fruit stops, this is noted in the softening of fruit once ripe. In apples for example more esterified forms of polysaccharide replace pectin once ripening begins.

Pectin is often used as a fat substitute in cooking, its properties allow flavour to be released more easily in comparison to other hydrocolloids. In 1825 Braconnot first isolated and identified pectin *(Lamport et al., 2011).* Prior to the 1900s pectin was exclusively used in the traditional manner, to make jams and jelly. However following Braconnots research the commercial production of pectin powder then became available.

Pectin is most frequently used for its gelling properties when combined with sugar. In high sugar concentrations it produces a firm jelly like texture, a desired texture in the preparation of jams and jellies. Paired with sodium alginate and sugar, pectin can produce different biopolymers which can result in transforming a structure of a gel (Sanchez, 2015).

The main culinary application of pectin is attained from the gelling properties which are affected by various elements such as concentration, pH, temperature, the modification of hydroxyl groups and the presence of cations (Nasrollahzadeh et el., 2019). This project aims to achieve the gelling of pectin at the lowest possible sugar concentration.

Aim

The aim of this project is to produce a lemon cheesecake using the Note by Note technique. This includes creating 3 visually distinct layers; a crumbly base, a creamy cheese like centre and a lemon flavoured pectin disc. The lemon flavoured disc should gel at the lowest possible sugar concentration.

Materials & Methods

Lemon Flavoured Disc

- 4g low sugar pectin (Polvo- Pectina Low Sugar) (Thickener: pectina, sucrose, stabiliser: calcium sulphate)
- 1g citric acid (Acide Citrique Monohydrate E330- Louis Francois)
- 100ml water
- 3g sucrose
- 1 drops of lemon oil flavouring (Lemon top note flavour drops- MSK supplied by MSK-ingredients) (pure compound)
- 2 drop of yellow food colouring (Juane citron-lemon yellow- by mallard ferriére)

1. Weigh out 100ml of water using a weighing scale.
2. Using a microscale, weigh out 4g of low sugar pectin and 1g of citric acid.
3. Disperse the citric acid followed by low sugar pectin in the cool water.
4. Begin to boil.
5. Once the solution reaches 100^{o}c remove from the heat.
6. Add the lemon flavouring and yellow food colouring compounds.
7. Place in a tray to cool down.
8. Allow to set for 1 hour before cutting using the 2inch round cutter.

Potato Starch Base (This, 2014)

- 50g potato starch
- 5g sucrose
- 5g vegetable oil
- 4 drops of chocolate fudge flavour compound (Iqemusu flavour compound)

1. Heat potato starch in a heavy pan stirring continuously for 4 minutes on a low heat.
2. Add the flavour compound to the oil.
3. Transfer the starch to a bowl and add the sucrose and vegetable oil mix.
4. Once cooled, compress together.
5. On a tray make the base 2cm high and cut out circles using the 2inch round cutter.

Cheesecake Filling

- 4 tbsp yopol (Texturas-powdered yoghurt supplied by infusions4chefs.co.uk) (Ingredients: hydrogenated plant fat, modified starch, sugar, milk proteins, powdered skimmed milk and citric acid)
- 0.25g sweetener (Puresweet- Powdered Erythritol)
- 3 drops of lemon oil flavouring (pure compound) (Lemon top note flavour drops- MSK supplied by MSK-ingredients)
- 1g agar (Texturas Gelification Agar)
- 2.5g xanthan gum

1. Place all ingredients in a large mixing bowl.
2. Using a mixer on speed 4, mix the mixture until thick.

Materials	
Weighing scales	Salter Glitter Digital Kitchen Scale Model: 5010777149074 
Micro scales	Silver Crest Digital Spoon Scales 

Pots	
Tray	
Round Cutter	
Pan	

Mixing bowl	
Cutlery	
Whisk	

Results

Sensory Analysis

A descriptive ranking test was undertaken to provide sensory analysis of the biscuit base, the pectin disc and cheesecake filling. 14 panellists partook in the sensory analysis, below are the findings.

Sensory Analysis of the Biscuit Base

0=not at all

1= weak

2=quite weak

3= moderate

4=quite strong

5=very strong

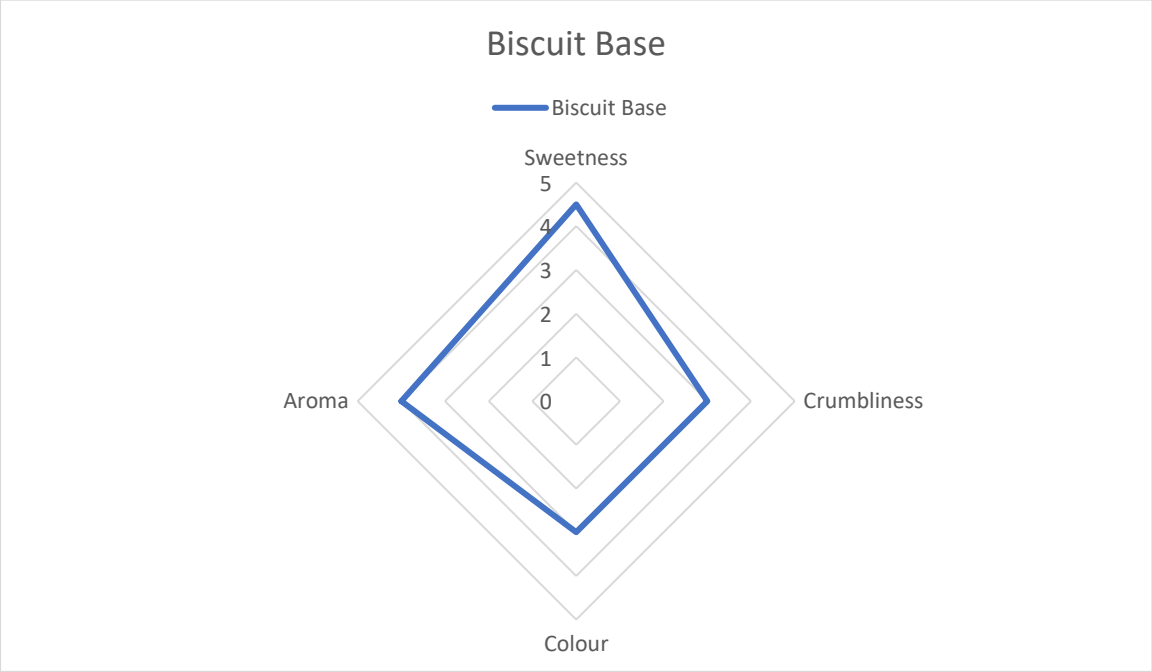

Illustration One: Sensory analysis of the biscuit base

As stated above sensory analysis was conducted using a descriptive ranking test. The biscuit base was prepared using potato starch as the principle compound. It was found to be sweet in taste. The texture was not as crumbly as expected, yet understandable due to the presence of oil. The colour of the biscuit base requires improving. It did not resemble a golden-brown colour as hoped and on doing this again a small amount of brown food colouring should be added. Overall the appearance of the base was enticing, and the combined ingredients resulted in a sweet aroma.

Sensory Analysis of the Cheesecake Filling

0=not at all

1= weak

2=quite weak

3=moderate

4= quite strong

5= very strong

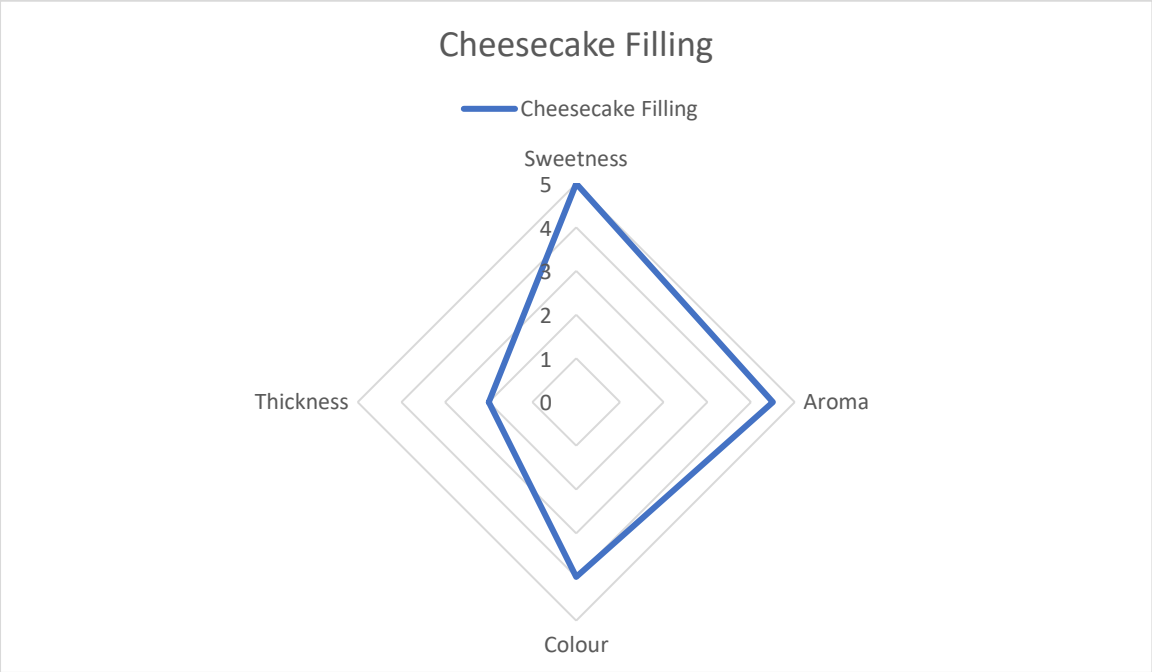

Illustration Two: Sensory analysis of the cheesecake filling

As shown in the diagram above, the cheesecake filling was very sweet. This attribute was attainted by the addition of powdered erythritol. The colour of the cheesecake was quite weak, it appeared to be white with a tint of yellow. The aroma of the cheesecake filling was quite strong, it had a zesty hint due to the addition of the lemon oil flavouring. With regards to thickness, the cheesecake filling was not thick enough to stand alone.

The pectin disc

0=not at all

1= weak

2=quite weak

3=moderate

4= quite strong

5= very strong

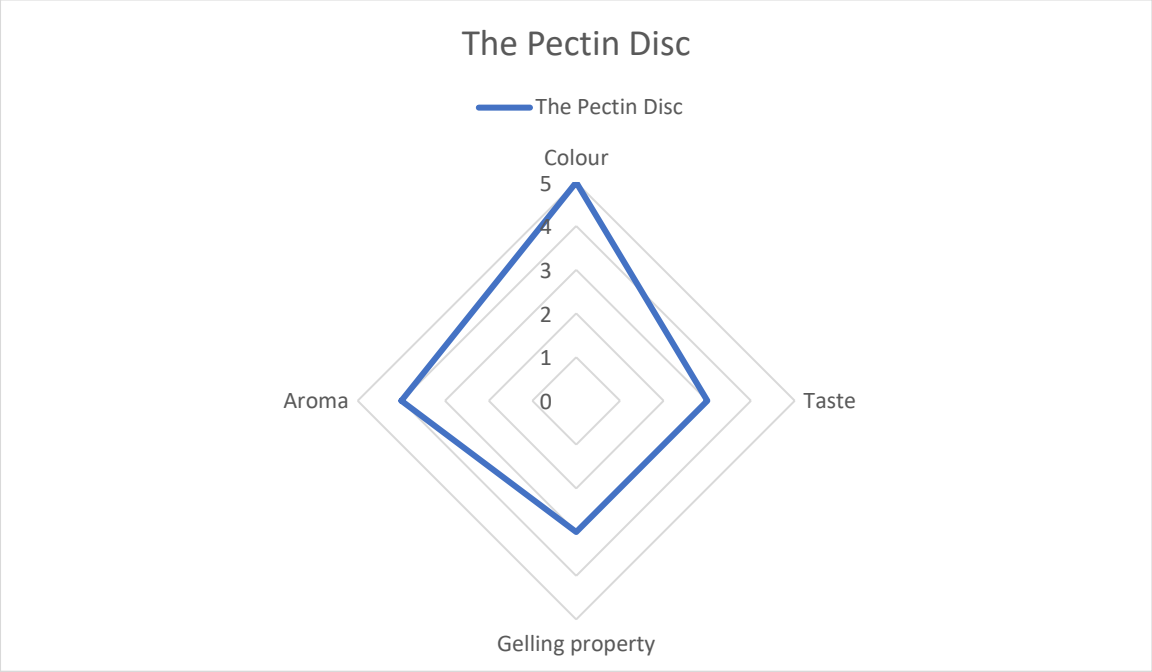

Illustration Three: Sensory analysis of the pectin disc

The sensory analysis of the pectin disc presented many discoveries, the appearance was bright yellow in colour. The taste was acidic, the disc lacked sweetness as a result of using small concentrations of sucrose. In relation to texture, the disc formed a weak gel structure. With regards to aroma, the pectin disc had volatile aroma compounds, these stemmed from the use of the lemon oil flavouring compounds. The pectin disc was composed of a zesty almost acidic scent.

Discussion

The results obtained throughout this process signified a variety of learnings. It demonstrated the gelling of pectin is aided by the presence of an acid, in this case, citric acid. Pectin forms a gel when dissolved in water under suitable conditions. It is derived from protopectin (insoluble) but becomes soluble as fruit ripens or is heated in the presence of an acid. Pectin is a negatively charged colloid, the addition of sugar reduces the pectin-water equilibrium. As sugar attracts some of the water, pectin chains become closer, resulting in the formation of a fibrous network (Smith,2003). The fibrous network supports liquids, thus resulting in gelling (Gardiner and Wilson, 2019) Hence, why pectin alone is rarely used for its gelling properties, these findings were demonstrated in the variety of recipes used to try determining the point at which pectin can gel at the lowest possible sugar concentration. As noted in week one, recipes without the use of an acid and sugar didn't gel. It can be concluded that this was a result of the absence of gelling promoters. In the production of jam and jellies alike, the sugar concentration varies from approximately 30% to 60%, this is required for the gelling process and helps act as a preservative. The recipe which created the pectin disc, gelled at much lower sugar concentrations. The pectin disc was prepared using mostly pure compounds; pectin, citric acid, water, sucrose and lemon aroma compounds however one compound, the yellow food colouring was not a pure compound, in order to illustrate the note by note technique, no impure compounds should be used in the recipe. A pure yellow compound may be used or no food colouring at all. As stated above in sensory analysis, the colour of the pectin disc was bright yellow, this was a consequence of adding the yellow food colouring, on preparing this dish again, a pure yellow compound should be used. This will result in meeting the brief regarding using the note by note technique. The disc proved to be very bright in colour, in addition to changing the type of food colouring used, smaller quantities should be demonstrated to resemble a lemon colour. The pure lemon compound, lemon oil flavouring, aided in the taste and aroma profile of the disc. The citrus essential oil is often extracted from the rind of fruit, volatile and semi-volatile compounds represent 85-95% of the entire oil fraction of the compound. The oil is represented by approximately 200 compounds of which, the most noted compounds are hydrocarbon and

Figure 1: The pectin disc prior to cutting

mono- and sesquiterpenes, these alongside many others help produce the flavour and aroma profile of the disc. *(González-Mas et al., 2019)*

Figure 2: The cheesecake filling

In contrast to the pectin disc was the creamy cheesecake filling, the main element being the yopol, powdered yoghurt. As noted above in *illustration two,* sensory analysis of this element was undertaken. It demonstrated how regarding aroma and sweetness the recipe flourished. This was a result of using the lemon flavour compound alongside the powdered erythritol. Erythritol is a polyol extracted from fruits such as pears and melon. It is a zero-calorie sweetener and is often used as high limits may be consumed without any side effects (Jamieson,2016). One of the main benefits of powdered erythritol concerning sensory attributes is it contributes a clean sweet flavour without any aftertaste. This was highlighted verbally with the sensory analysis panellists. Although the aroma and taste profile demonstrated promising results, the main disadvantage of the recipe was in relation to the texture. The filling lacked the thickness required to stand alone whilst supporting the pectin disc. Xanthan gum and agar, both used in the recipe, have thickening properties, however unlike xanthan gum, agar requires heating in order to thicken and gel. The recipe lacked a heating element. Perhaps by heating the agar to 90^{o}c first, the cheesecake filling would be thick enough to hold structure. Starches are also commonly used thickening agents, amylose or amylopectin for example may be used to help thicken the recipe and satisfies the note by note cooking technique, amylose is a linear polymer of glucose whereas amylopectin is a multibranched polymer, therefore, amylose makes stronger hydrogen bonds than amylopectin *(Jackson, 2003).* Thus, of the two amylose has the better thickening properties. On producing this recipe again, amylose may be used to produce the desired consistency.

The final component of the dish was the biscuit base. As illustrated in the sensory analysis above, the recipe used to reproduce a biscuit base worked well. The recipe was derived from This' note by note recipe for biscuits. Regarding sweetness, sucrose was used for the sweet taste as well as coarse texture to aid in the crumbliness of the biscuit. Sucrose is a crystalline powder, coarser in texture in comparison to other sweeteners, alongside the potato starch, it helped to create a biscuit like texture. The chocolate fudge flavour compound accompanied the sucrose well in the dish. It resulted in adding to the sweetness whilst providing a strong flavour which helped to mask the undesirable potato flavour from the potato starch. Although the biscuit base was not as crumbly as initially desired, it very closely resembled the density and texture of a cheesecake base.

Figure 3: The biscuit base

Conclusion

In conclusion, a deconstructed lemon cheesecake was produced, the pectin disc was created using low sugar pectin, citric acid, water, sugar, food colouring and a pure lemon flavour compound. The brief was met as a result of gelatinisation of pectin at the lowest possible sugar concentration, although a weak gel structure was formed, the gelling process was aided by the presence of citric acid. The final sensory analysis signifies this. The cheesecake filling was produced following the note by note technique, pure compounds were used to resemble a cheesecake filling. With regards to taste and aroma, the pure compounds used satisfied these senses. However, in relation to trigeminal sensation, the pure compounds didn't fulfil these requirements. The texture was too wet and lacked structure, this was evident in the final stage of constructing the cheesecake. The base of the cheesecake had a desirable aroma and taste profile. However, the chosen compounds were less effective with regards to re-creating a crumbly texture.

Recommendations

On carrying out the note by note technique again, it is advised that the properties of the ingredients are studied in detail prior to use. This will potentially allow for the manipulation of the properties of pure compounds, for example, agar was used in the cheesecake filling recipe as a thickening agent however, the recipe lacked a heating element. This hindered the thickening properties of agar. With regards to following a note by note technique, great emphasis should be placed on research to establish pure compounds that may be used as an alternative to impure compounds. This was illustrated in the pectin disc recipe whereby an impure compound, food colouring, was used and offered no reconstruction elements. A pure yellow colour compound should have been identified prior to construction of the disc. In relation to the gelling of pectin at a low sugar concentration, a method to determine the sugar concentration in the final recipe should be used. The lack of knowledge regarding the sugar concentration of the pectin is a large variable, although it seems the pectin demonstrated gelling properties at a low sugar concentration, as the sugar concentration of the pectin was unknown, this provides many uncertainties regarding the brief.

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Appendices

Log Book

Week 1

Aim

The main aim this week is to identify ingredients that aid gelatinisation whilst sugar concentration is low.

Objectives

- To test a variety of ingredients to determine the gelling promoters of pectin at a low sugar concentration.
- To determine a suitable note by note flavour compound to create a desirable flavour for the cheesecake.
- To identify the quantity of food colouring which should be added to the gel to make an enticing yellow colour.

Materials & Method

Equipment:

- Cutlery
- Bowls
- Whisk
- Hob
- Weighing scales
- Micro scales
- Tray
- 2inch cutter

Slow Set Pectin A

- 3g slow set pectin
- 97ml of water
- 1g citric acid

Slow Set Pectin B

- 1.5g slow set pectin
- 87ml of water
- 1g calcium
- 10g sucrose

Low Sugar Pectin A

- 1.5g pectin
- 93ml water
- 1g citric acid
- 5g sucrose

Low Sugar Pectin B

- 3g pectin
- 0.5g citric acid
- 94ml water
- 2g sucrose

Low Sugar Pectin C

- 2g pectin
- 5g dextrose
- 0.5g citric acid
- 1g agar
- 2 drops of lemon oil favouring

Fruit Pectin A

- 2g pectin
- 1g agar
- 1g calcium
- 94ml water
- 4 drops of lemon oil flavouring
- 2 drops of food colouring

Fruit Pectin B

- 4g pectin
- 1g citric acid
- 3 drops of lemon oil flavouring
- 1 drop food colouring

Method:

1. Turn the hob onto heat 4.
2. Place all ingredients except lemon oil flavouring in a pot and begin stirring.
3. Once boiled to 100^{o}c remove from the heat, add the lemon oil if stated in the recipe and mix.
4. Place in a shallow tray and allow the pectin to set.

5. Undergo informal sensory analysis to determine the best gelling at lowest sugar concentration.

Equipment:

- Weighing scales
- Microscales
- Bowls
- Pots
- Pans
- Cutlery
- Whisk
- 2inch cutter
- Tray

Results

The slow set pectin using recipe A showed promised results initially, in comparison to other recipes it began to thicken quicker. After the pectin was set, it proved to form an unstable gel structure which fell apart while trying to shape. The low sugar pectin proved to work best with higher concentrations of pectin. As the concentration of pectin increased as did the stability of the gel.

Recommendations for next week

Next week, emphasis will be placed on trying to produce a stable, firm gel. Low sugar pectin recipes should be modified using higher pectin concentrations and to identify gelling promoters as the low sugar pectin proved to work best with lower sugar concentrations, meeting the aim of the brief.

Figure 4: Recipe A using different quantities of food colouring

Week 2

Aim

The main aim this week was to modify the low sugar pectin recipe to produce a stable gel.

Objectives

- To being making all layers of the cheesecake.
- To determine a suitable recipe to use for the biscuit base of the cheesecake.
- To establish a recipe suitable for the cheese cake filing.
- To begin the assembly of the cheesecake.
- To complete sensory evaluation of the cheesecake.

Materials & Methods

Equipment:

- Cutlery
- Bowls
- Whisk
- Hob
- Electric whisk
- Weighing scales
- Micro scales

Polyphenol Caramel Disk (This, 2014)

Ingredients:

- 100g fondant
- 70g glucose
- 3g polyphenols
- 10g cocoa butter

Method:

1. Heat 100g fondant and 70g glucose until the mixture reaches an internal temp of 120 degrees
2. Add 3g polyphenols and continue cooking the sugar to a temperature of 155 degrees.
3. Remove from the heat and add 10g cocoa butter.
4. Transfer to wax paper, shape into a disk and press down a thickness of 1mm.

Lemon Flavoured Disc

- 4g low sugar pectin (Polvo- Pectina Low Sugar) (Thickener: pectina, sucrose, stabiliser: calcium sulphate)
- 1g citric acid (Acide Citrique Monohydrate E330- Louis Francois)
- 100ml water
- 3g sucrose
- 3 drops of lemon oil flavouring (Lemon top note flavour drops- MSK supplied by MSK-ingredients)
- 1 drop of yellow food colouring

1. Weigh out 100ml of water using a weighing scale.
2. Using a microscale, weigh out 4g of low sugar pectin and 1g of citric acid.
3. Disperse the citric acid followed by low sugar pectin in the cool water.
4. Begin to boil.
5. Once the solution reaches 100^{o}c remove from the heat.
6. Add the lemon flavouring and yellow food colouring compounds.
7. Place in a tray to cool down.
8. Allow to set for 1 hour before cutting using the 2inch round cutter.

Potato Starch Base (This, 2014)

- 50g potato starch
- 5g sucrose
- 5g vegetable oil
- 4 drops of chocolate fudge flavour compound (Iqemusu flavour compound)

1. Heat potato starch in a heavy pan stirring continuously for 4 minutes on a low heat.
2. Add the flavour compound to the oil.
3. Transfer the starch to a bowl and add the sucrose and vegetable oil mix.
4. Once cooled, compress together.
5. On a tray make the base 2cm high and cut out circles using the 2inch round cutter.

Cheesecake Filling Using Yoghurt Powder

- 4 tbsp yopol (Texturas-powdered yoghurt supplied by infusions4chefs.co.uk)
- 0.25g sweetener (Puresweet- Powdered Erythritol)
- 3 drops of lemon oil flavouring (Lemon top note flavour drops- MSK supplied by MSK-ingredients) (pure compound)
- 1g agar (Texturas Gelification Agar)

- 2.5g xanthan gum

1. Place all ingredients in a large mixing bowl.
2. Using a mixer on speed 4, mix the mixture until thick.

Cheesecake Filling Using Milk Powder

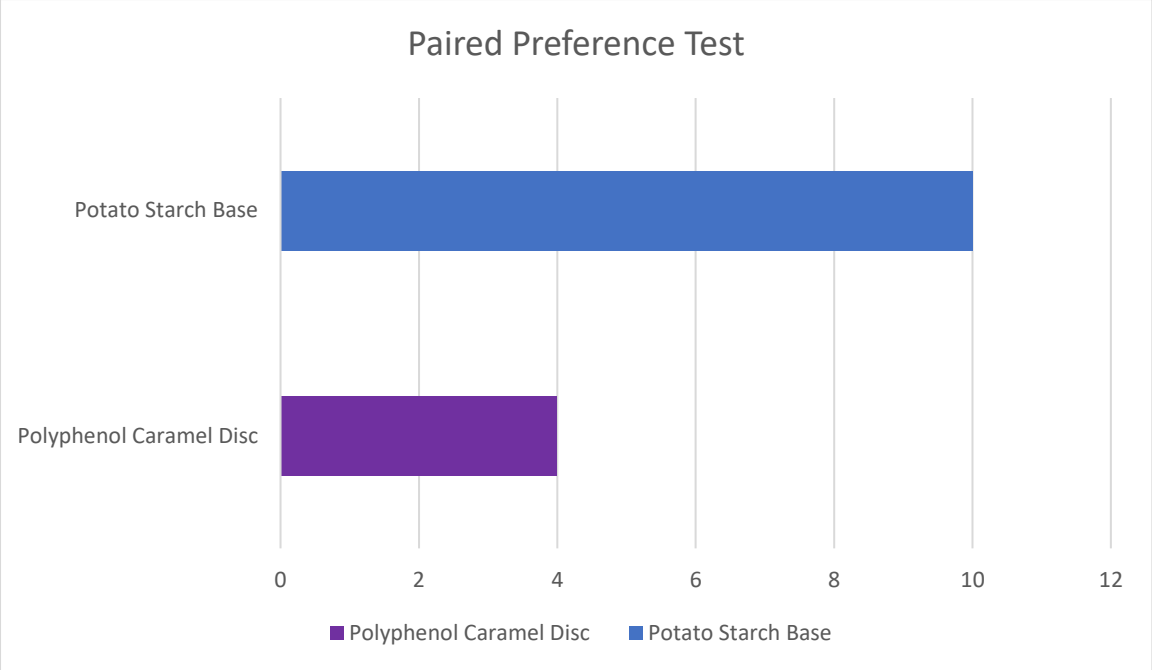
- 30g milk powder
- 2.5g xanthan gum
- 5g sucrose
- 15g water
- 3g agar
- 1 tbsp rennet powder
- 3 drop of lemon oil flavouring (pure compound)

1. Boil the water and agar in a hob.
2. Remove from heat, once cooling, add sucrose and xanthan gum.
3. Finally add the rennet and milk powder one table spoon at a time whist whisking.
4. Whisk continuously until a thick mixture is produced.

Sensory Analysis

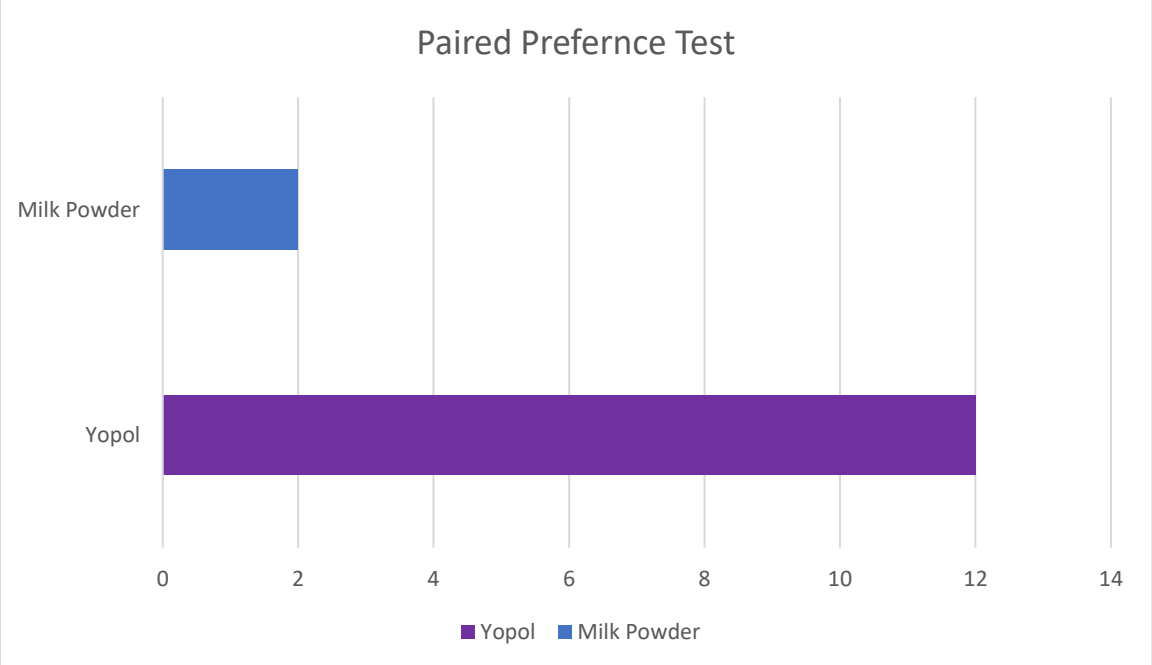
Paired Preference test between both cheesecake option fillings.

Polyphenol Caramel Disc	4
Potato Starch Base	10



Paired Preference test between cheesecake filling using yopol vs milk powder

Cheesecake filling using yopol	12
Cheesecake filling using milk powder	2



Results

This week resulted in great advancements with regards to recipes, although the polyphenol caramel disc proved to be too thin and didn't layer up great to achieve a biscuit like base, the trial and error of a variety of recipes proved beneficial. The recipe for the biscuit base using potato starch resembled the biscuit base of a cheesecake and will be used in the final recipe.

These results were reiterated in the sensory analysis obtained during this week. 10 of 14 people preferred the potato starch biscuit base in comparison to the polyphenol biscuit layers. The original plan to use milk powder as the main component of the base resulted in a runny consistency, the texture resembled a liquid and proved to be unsuitable for the dish. This was not appropriate for the centre of the cheesecake. The cheesecake filling recipe using yopol proved to be much thicker in consistency and had a better flavour profile although the texture was still too runny to allow the filling to stand alone with the pectin disc on top. 12/14 people preferred the yopol cheesecake centre in comparison to the milk powder. With regards to the pectin disc, a gel was formed using the modified recipe from week one, however it had a weak gel structure and requires some modification in order to become a stable gel.

Recommendations for next week

Next week the cheesecake filling recipe should be modified to produce a thicker consistency. This is potentially achievable by heating the agar to 90^{o}c and the xanthan gum to 60^{o}c prior to mixing all the ingredients together. By allowing the xanthan gum and agar to reach these temperatures, it results in gelling properties which could result in a more stable structure. With regards to the biscuit base, a brown food colouring may be added to produce a more desirable colour. The pectin disc should be made without the addition of the lemon oil flavouring or yellow food colouring as perhaps it is hindering the gelling process of the pectin.

Photographs

Figure 5: Slow set pectin

Figure 6: Chocolate fudge compound

Figure 7: Powdered Erthritol

Figure 8: Yellow food colouring

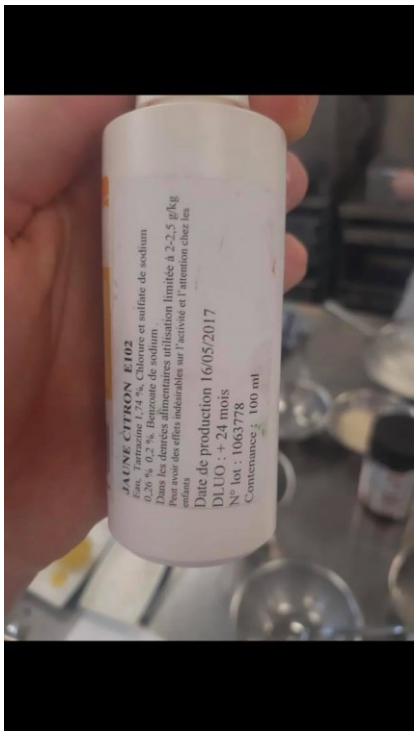


Figure 9: Yellow food colouring

Figure 10:Pectin

Figure 11: Pectin

Figure 12:Pectin

Figure 13:Construction of the cheesecake

Figure 14:Yopol, powdered yoghurt

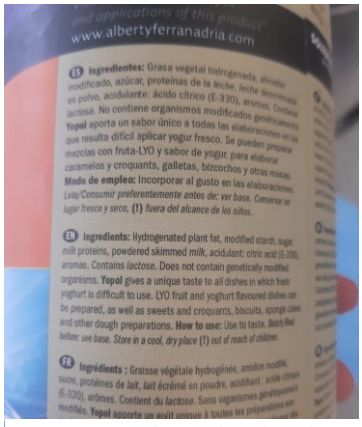


Figure 15:Yopol, powdered yoghurt

Figure 17:Fruit pectin

Figure 16:Lemon oil flavouring, pure compound