Molecular Gastronomy

NOTE BY NOTE REPORT: TOMATO SOUP WITH POTATOES

David Martínez Rodríguez
D21127089

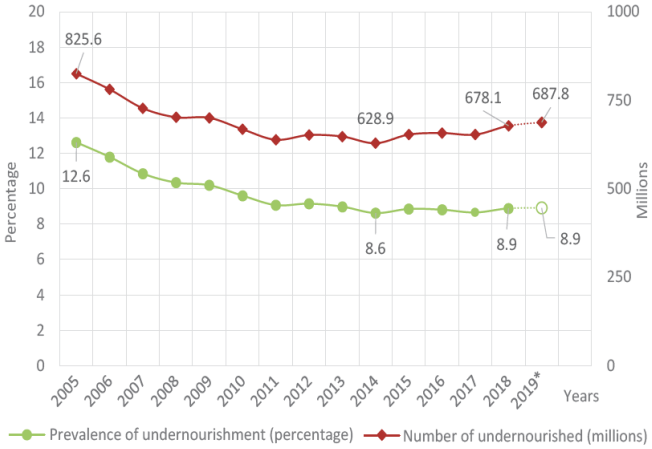
May 9th, 2022

TABLE OF CONTENTS

1. INTRODUCTION

Continuously, since 1950, the world's population has consistently risen, going from 2.5 billion people to 7.75 billion by 2020 (Statista, 2021). But not only that, following this alarming rate, it is expected that by 2100 the world's population will reach the astonishing number of 10.87 billion.

For that exact same reason, if population growth continues at this pace, food production must increase by 70% by 2050 (Askew, 2017). This is something that, even though technology is at its highest, is starting to become a big concern. Despite the efforts done to reduce the number of undernourished people, just in 2019, 8.9% of the world population (almost 690 million individuals, 144 million being children under the age of five) were undernourished. (Figure 1). And what is even more worrisome, is that from 2014, the number has done nothing but increase, year after year. These numbers can be due a lot of factors, such as armed conflicts, humanitarian crisis, climate change, population growth, and pest infections. At the same time, the COVID-19 pandemic is expected to have had an even bigger impact on these numbers, as it can be seen in Figure 2, where in the general, food security is at with worst now (Figure 2).



Source: Adapted from Food and Agriculture Organization of the United Nations (FAO) and others, The State of Food Security and Nutrition in the World 2020, figure 1.
Note: Values for 2019 are projected.

Figure 1. Global number and percentage of undernourished persons, 2005 – 2009 (UN, 2021).

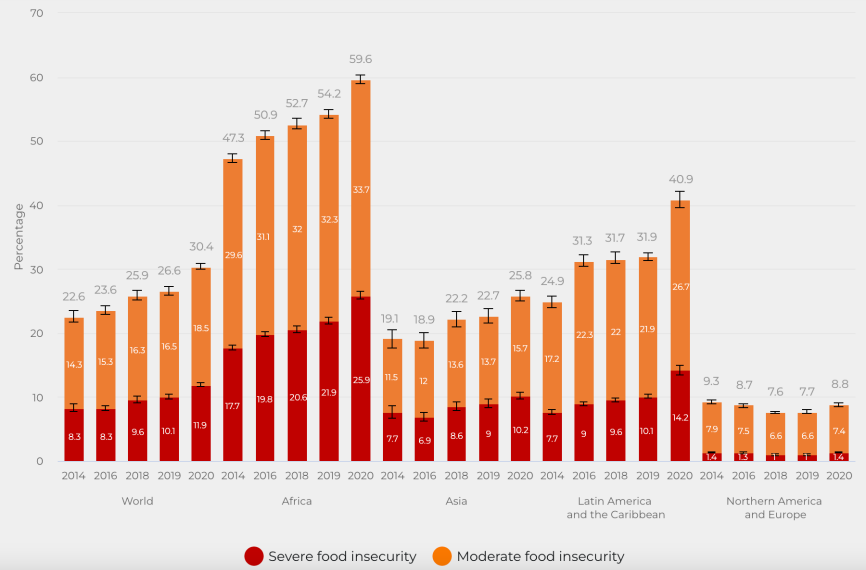


Figure 2. Moderate or severe food insecurity has been climbing up slowly for six years and now affects more than 30 percent of the world population (FAO, 2021).

To elaborate more on the factors previously mentioned, it is clear that one key reason why there are so many people around the world suffering from food insecurity and hunger is because food systems are increasingly vulnerable, and because they cannot afford the costs of a healthy diet (UN, 2021). Our current systems just cannot keep up with the velocity at which we are increasing our population. Just to produce food, we occupy 50% of the inhabitable land on Earth, we consume around 70% of our fresh water and we produce a quarter of the global greenhouse gases emissions. And not only that, to add insult to injury, around 30% of the food produced go to waste, and that also comes at a cost for the environment and the people.

So, the answer is pretty clear: something must be done, sooner rather than later. According to the Food and Agriculture Organization (2021), there is a series of pathways that can be followed to reduce these statistics, with one of them being "strengthening food environments and changing consumer behavior to promote dietary patterns with positive impacts on human health and the environment."

We could expand a bit further on that, and it is open to interpretation, but when it comes to changing consumer behavior to promote new dietary patterns, a lot can be done, and the journey ahead is a long one. Some technologies, like using genetically modified organisms, have been proposed and that has shown to increase agriculture productivity,

but their sustainability implications are object of controversy. On the other side we have molecular gastronomy, a food science discipline that focuses on the physical and chemical phenomena that occur during culinary processes (This, 2009). This is relevant because, through these understandings, one is able to generate knowledge on the basis of these molecular transformations and explain why the food changes the way it does while cooking (This, 2005). And how can that help solving this food insecurity problem? Or how do this relate to this changing consumer behavior?

Zooming in a little bit, we have what is known as note by note cooking, which is an application of molecular gastronomy that instead of using actual ingredients to cook, uses pure compounds or mixtures of pure compounds. This technique was first introduced in 1994 by Hervé This and has the objective of creating food "from scratch" (This, 2016). Producing foods using only pure compounds can lead to hundreds of new dishes, all dependent to the creativity of the cook. By doing this, it is possible to cook without using actual plants or animals, because we only need their compounds. In the end, these dishes can have the same texture, flavor, odor, appearance and sensations as their "plant or animal" counterparts.

Note by note cooking opens up a new solution to fight food shortage back. Not only because it is easier to work only with pure components, but because by doing so, food waste can also be reduced. Spoilage would no longer be a major problem, and the quality of the food would be maintained for longer periods of time.

Taking all of this into account, the following report will provide an in-depth analysis of a note by note recipe (tomato soup with potatoes) that will explore different things. At first, the recipe itself will be discussed, along with the why each ingredient was chosen and used the way it was used. On the other hand, the actual presentation of the dish will be shown and described. As mandatory requisites, there should be some sort of cube in the dish, which in this recipe it was the potatoes; and there should be a fiber as well, which is pectin also found in the potatoes. Last, but not least, a general sensory evaluation description and analysis will be shared, based on observations made by TU Dublin students, in order to understand if the dish does indeed taste, feels and make people believe that they are trying actual tomato soup.

2. AIM OF THE REPORT

In accordance with the note by note cooking technique, highlighting its relevance and importance for the not-so-distant future when it comes to food shortage, the aim of this project is to propose and develop a note by note recipe of a food dish: tomato soup (spicy) with cube-shaped potatoes, that also tastes good and that looks like the made-with-actual-ingredients counterpart.

To achieve that, a series of objectives are expected to be followed, which will in turn be discussed in detail throughout this report:

- A recipe will be developed, tried and adjusted in the kitchens of TU Dublin
- Weekly objectives will be established, in order to achieve the proposed aim of this project
- Quick sensory analysis will take place at the end of each trial, with a petite committee of around five to six TU Dublin students, to better understand the product perception and which changes need to be made
- Adjustments will be made the following week after the quick sensory analysis, taking comments into account, as well as the available equipment and ingredients
- An analysis of the final dish will be conducted to determine if all the ingredients used are in compliance with the EU regulations
- The final product will be further analyzed, mainly for its appearance, texture, flavor and aftertaste
- To allow its replicability, the ingredients, as well as the brands, will be shared along with the quantities and equipment used

As stated above, this report will provide a better general overview of the product, by exploring and discussing in more detail the findings, proposing next steps, as well as general conclusions and recommendations.

3. MATERIALS AND METHODS

The recipe consists of two main parts: a tomato soup and the cube-shaped potatoes. Both are prepared at different times, using different ingredients and different equipment. Because of this, both parts were prepared individually and then put together in the end. Table 1, as described below, enlists in great detail the ingredients used for the tomato soup, while Table 2 describes the same for the cube-shaped potatoes.

Table 1. Ingredients for the tomato soup.

Ingredient	Picture	Brand	Purpose
Water	-	From the lab	To provide the liquid texture of the soup
Xanthan gum		En Place	For thickening the texture, to reduce the "watery" perception of the soup
Onium flavor		IQEMUSU	To enrich the flavor with spices
White pepper		Schwartz	To enrich the flavor and sensation of the product by making it a bit spicy

Tomato flavor		Sosa	To provide the main flavor
Salt	-	From the lab	To highlight the flavors in general and increase the sensorial experience

Table 2. Ingredients for the potatoes

Ingredient	Picture	Brand	Purpose
Water	-	From the lab	For texture, to provide the water present in potatoes
Maltodextrin		Sosa	For texture, to thicken the product by acting as a carrier for the pectin
Pectin		Sosa	Dietary fiber needed in the recipe and agent that solidifies the product

Potato powder		Knorr	To provide the main flavor
White pepper		Schwartz	To enrich the flavor and the appearance
Citric acid		Louis François	To acidify the potatoes, for flavor
Yellow color		Cake Decoration	To provide the characteristic potato color to the product
Salt	-	From the lab	To enrich the flavor and sensation of the product

In addition to the ingredients used, in order to prepare the product, the recipe needed to use specific equipment. All of these, to be used for a specific purpose. To highlight the tools employed, Table 3 describes in-depth everything that was needed, and why they were needed.

Table 3. Equipment and tools used for the product.

Equipment	Brand	Purpose
Scale	Dunnes Home	To weigh all compounds needed for the recipe
Handheld mixer	Tellier	To mix the compounds needed for the soup
Bowls	-	As containers to use when working with the soup and the potatoes
Stove	Electrolux	To mix the compounds needed for the potatoes and ensure the agar-agar works properly
Molds	-	As a container for the potatoes and to facilitate its cutting into cubes
Freezer	KBR	To cool down the potatoes and allow them to be cut

Finally, as stated before, all these ingredients and equipment were used to elaborate the final dish. To understand the changes that were done (not the final recipe), please go directly to Appendix – Logbook. For the final product, the soup and the potatoes were prepared at different times and then put together in the end. In alignment with that, the methodology followed for each part of the final dish was:

Tomato soup:

1. Weigh all the ingredients with the scale.

2. Using a handheld mixer, mix 200 mL of water with 1 gram of xanthan gum until well homogenized, taking care of the amount of air bubbles.
3. Add 12 grams of tomato flavor and 2 grams of white pepper and mix well.
4. Add 2 drops of onium, along with 2 grams of salt and mix.
5. Pour the soup into a plate and let it chill for the air bubbles to set.

Potatoes:

1. Weigh all the ingredients with the scale.
2. Mix 120 grams of maltodextrin, 4.5 grams of pectin, 30 grams of potato powder, 2 grams of white pepper and 2 grams of salt in a bowl.
3. In the stove, add 150 mL of water slowly to the product and the yellow coloring, while mixing thoroughly for a couple of minutes.
4. Add 1 gram of citric acid and continue mixing until the product starts to boil.
5. Put it into molds and store it in the freezer for around 15 minutes at -15 ºC.
6. Cut the potatoes into cubes and put them on top of the tomato soup.

4. RESULTS

4.1 Final product

Even though the product development was supposed to take four sessions in the kitchen (from end of March to end of April), some changes in the schedule had to be done due to a having a positive COVID-19 test after the first session. Because of that, the results that are about to be presented, and discussed, come from only being two days in the kitchen (as it can be further analyzed in Appendix – Logbook, where the changes between both days are explained in more detail).

With that being said, the final product (Figure 3) is a note-by-note dish that is made up of two main parts: a tomato-flavored soup, with some cube-shaped potatoes on top, both a bit spicy. This is intended to be eaten with a spoon, though it is up to the consumer to eat the potatoes separately, using a fork and/or a knife.

Figure 3. Tomato soup with cube-shaped potatoes, decorated with some more potatoes on top of the plate. Cooked using the note-by-note technique.

In order to follow the note-by-note methodology, compounds (enlisted in Materials and Methods) were used rather than actual ingredients, to develop this product. The soup has a semi-liquid texture due to the use of xanthan gum and it is easy to manipulate with a spoon, and in the mouth. On the other hand, the color was achieved not by the use of food colorings, but by the tomato flavor, because its use was enough to provide some color to the product. In addition to that, the flavor was of tomato, but with some garlic (provided by the onium flavor by IQEMUSU) and slightly spicy (provided by the chili by Schwartz) notes.

The potatoes, the second part of the dish, gained their color by some yellow coloring (Cake Decoration), and it has some dark spots all around, provided by the chili that is also involved in the flavor. To expand a bit more on the latter, potato powder was employed, which gives the characteristic potato flavor to the product. To round up the general flavor, citric acid was added to the recipe, giving an acidic profile to the dish. Finally, the texture is solid, and easy to cut when cold down in the freezer, and that was achieved with the use of pectin (1.5 % of the total volume) and maltodextrin (40% of the total volume).

Last, but not least, as part of the requisites this dish needed to have, the potatoes were cut in cubes, to add a geometric aspect to the final product; and pectin was also added to be employed not only to provide some texture, but also to act as the dietary fiber of the recipe.

4.2 Sensory evaluation

To evaluate the overall acceptance and performance of the product, a qualitative evaluation was performed with six TU Dublin (FIPDes) students, who stepped in as consumers. For that reason, a series of questions involving general observations for appearance, texture, flavor and aftertaste, were asked directly to them. No scale in particular was followed, since only verbal comments were tracked.

A spoon for each of the consumers was provided, along with some water and a napkin. The evaluation was in-person, and in the kitchen of TU Dublin. The session was conducted as a kind of focus group, where all consumers tried the product at the same time and reached a general consensus of what they perceived for each one of the main attributes analyzed.

According to what was found, the soup is perceived as appealing to the eye, though some consumers would rather eat it without the potatoes inside the soup. Still, they believe the potatoes are a nice addition and provide a different eating experience. The color of both, the soup and the potatoes were considered accurate and similar to what they tried to emulate, with especial attention to the dark dots in the potatoes.

For the texture, they generally appreciated the multitexture experience of biting the cubes while swallowing the soup. The semi-liquid, but still viscous enough, tomato soften

the potatoes to make them easier to break in the mouth, which turned out to be easier to handle against eating them separate from the soup. Some consumers clarified that, even though they would have liked the soup to be slightly more liquid, the texture was still appropriate to what a tomato soup could be. Additionally, the potatoes, though hard in the first bite, become easier to bite and swallow later on.

The flavor was something that consumers seemed to focus on more. The tomato was well liked, with some students highlighting the soft spicy touch at the bottom of the mouth, where it remained for a while even after swallowing. It was described as a nice experience, and one that did not saturate the product. The tomato flavor was strong, but balanced, especially when eaten with the potatoes. The aftertaste in general was liked, as it did not stay for too long.

The potatoes, on the other hand, were liked for its strong potato feeling, but they were also perceived as a bit too acid. These differences were stronger when tried alone, but consumers agreed that when tried with the soup the acidity was not bothersome. If there was any aftertaste after a couple of minutes of eating, it was mainly the acid sensation in the tongue, which was not liked nor disliked by the students.

4.3 Final product cost

To have a better perspective and overview about the feasibility of the product, some costs estimates can be obtained by taking into account the ingredients used for the dish enlisted in Materials and Methods (with their corresponding brands), as well as the quantities used for the final product (Table 4).

Table 4. Final product costs for the tomato soup with potatoes.

Item	Quantity	Unit	Price (in €)	Quantity in recipe	Price in recipe (in €)	References
Xanthan gum	100	g	3.19	1	0.03	(SuperValu, 2022)
Onium flavor	50	mL	15	0.5*	0.15	(IQEMUSU, 2022)
White pepper	425	g	14.73	4	0.14	(Conaty, 2022)
Tomato flavor	600	g	17.58	12	0.35	(Henley Bridge, 2022)
Salt	750	g	0.44	4	0.002	(SuperValu, 2022)
Maltodextrin	500	g	4.91	120	1.2	(Cocineros, 2022)

Pectin	500	g	27.59	4.5	0.25	(Cocineros, 2022)
Potato powder	204	g	2.09	30	0.30	(Tesco, 2022)
Citric acid	1000	g	24.95	1	0.02	(Gourmet Versand, 2022)
Yellow color	25	mL	1.49	1.5 mg*	0.00009	(SuperValu, 2022)
Total	**-**	**-**	**-**	**-**	***2.44***	

*Approximate quantities

As it can be observed in the previous table, to develop the product there would be needed a total of €2.44 euro per dish. This is considering that this is a product that should be eaten at the moment is being served, at a restaurant, not as something that consumers would buy prepacked at a supermarket. For that reason, no transportation, nor package costs, are taken into account. There might be some storing costs that could be eventually added to the final cost, but the assumption here was that those were zero for the purposes of this report.

With this final product cost, it can be observed that the soup is considerably cheap, and can be sold at a higher cost, similar to the prices that can be found in the market, representing a good opportunity to exploit.

4.4 Future development

Based on these results, if further changes and fine tunings are to be made, there are several options or paths that can be followed.

- Quantitative sensory evaluation:
    - To increase the number of consumers to get statistically significant results
    - To expand on the qualitative results, by applying a questionnaire with quantitative scales
    - To use liking/preference questions (9-point hedonic scale) along with just about right questions (5-point scale)
    - To test not only this formula, but some others with some of the comments that have already been gathered, in order to make proper comparisons between the samples

    - To use this information, in addition to the one previously explained, to make improve the recipe and adapt the formula to the consumer's expectations and needs
- Product optimization:
    - To improve soup's texture by making it possibly slightly more liquid
    - To enrich soup's flavor by increasing the garlic notes, which were not significantly perceived during the qualitative sensory evaluation
    - To reduce, or remove, the citric acid from the potatoes
    - To evaluate if there is a way of increasing the overall flavor of the potatoes, while also providing some sort of color just like with the soup, to remove the yellow coloring agent from the recipe
    - To analyze if, in addition to the potatoes, other toppings can be used, such as cheese. Some consumers played around the idea of having a warm tomato soup with cheese, that could be eaten with a slide of bread that you can dip into the product

5. DISCUSSIONS

Note by note, as a molecular gastronomy application, aims at the idea of making dishes entirely from pure compounds or mixtures of them, with no meat, fish, fruits or vegetables allowed in the recipes (Burke et al., 2016). And even though this technique can be used to create new foods and flavors, it can also be employed as a way to emulate already existing products, just as it was in the case of this report. This has a lot of advantages, especially when taken into account the dangers of overpopulation and food insecurity.

A tomato soup, with potatoes, was developed over the course of several weeks, using different compounds that tried to imitate the original dish to a certain degree of success as the qualitative sensory analysis indicated. In order to do so, several compounds were proposed and used.

The dish splits in two, the tomato soup and the potatoes. For the former, xanthan gum (E 415) was critical to achieve its characteristic texture (EFSA, 2017). This is a high molecular weight polysaccharide gum commonly used as a food additive, which according to the Regulation EU 257/2010 does not possess any safety concern for the general population, reason why there is no acceptable daily intake (ADI). The molecule has several advantages, useful for this kind of product, like it is soluble in cold and hot water, though it needs intensive agitation upon introduction into the water (Katzbauer, 1998). During the development of this product, it was needed to use a handheld mixer to fully incorporate the gum within the medium, and because of such agitation, several air bubbles were generated, and the product had to be left standing still, to allow them to set. Having such properties give xanthan gum the versatility to be used as stabilizer and thickener, which is an addition reason why it was chosen as a compound to stabilize this soup.

On the other hand, in compliance with the Guidance on Flavorings (2012) by the Food Safety Authority of Ireland, food flavorings that comply with the requirements of Regulation EU 1334/2008, Article 4 (“flavorings can only be used if they do not pose a safety risk to the health of the consumer”), there are no maximum level for the majority of the food flavorings, with the exception of some very specific compounds. After reviewing Table 2.4 of that guidance, it can be confirmed that neither of the flavorings used in this recipe (tomato flavor, onium, white pepper and potato powder) has a

maximum authorized level. With these observations, it can be concluded that the quantities used for the flavors in both, the soup and potatoes, do not represent any sort of risk to the consumers.

In addition to that, though coloring is avoided for the majority of the recipe (no red color was used for the soup), some yellow coloring was applied for the potatoes, to give them their recognizable appearance. It is the Regulation EU 1333/2008 the one that dictates not only where food colors can be used, but also the quantities that can be employed. At first, the tomato soup used color, but then it was observed that the tomato flavor was enough to color the soup, and that is also in compliance with the Table 2 of the Annex II of the previously mentioned regulation, which states that no food coloring is permitted in any tomato-based sauces per the Article 18(1)(a). Even though this is not exactly a sauce, in order to avoid any sort of confusion with the consumers, it was chosen to align the product to this statement.

But as mentioned before, yellow coloring was used, and there is a maximum level allowed. It is important to highlight that the color employed does not specify what kind of yellow it is, so for that reason it was decided to work with it as if it were Group IV Sunset Yellow (E 110), the most critical color out of the yellows listed, where no more than 5 mg/L or 5 mg/kg are allowed. The total weight of the potatoes is of around 310 grams, and even though it proves to be a bit difficult to measure small quantities, using the rule of three we know the maximum quantity of color allowed is of approximately 1.5 mg / 300 mg of product, which is what was tried to be weighted in the shape of a very small drop (the color came as liquid). That quantity showed to be more than enough, as it can be seen in Figure 3.

To get a good texture, the potatoes required a small quantity of pectin. This is a complex starch derived from plants, such as potato too. It has wide applications in the industry, such as acting as an emulsifier, gelling agent, thickener, stabilizer, and more (Vanitha & Khan, 2019). The pectin it was worked with came from Sosa, a Spanish brand, that stablishes that in order for it to work, without generating any sort of lumps, it needed high temperatures (around 80 to 85 ºC) and it needed a carrier, such as maltodextrin (Sosa, 2020). To achieve the gelling effects, 1.5% of the total volume had to be pectin, reason why 4.5 grams were used. Not only that, around 40% of maltodextrin had to be

added, which translates into 120 grams. Citric acid is also advised, which was also used to round up the general flavor profile of the product.

When it comes to the sensory perception of the product, it has been found that for soups, “soft”, “familiar”, “comfortable”, “light” and “salty” are attributes and emotions that are generally liked and accepted by consumers (Ryoo et al., 2020). These kinds of products are associated with something that has a soft texture, which goes in accordance to what was found in this sensory evaluation, where the product developed was easy to handle with a spoon and to swallow. Because of the flavor balance, this is also a product that can be identified as light, though some improvements could be made on the saltiness that could also be expected.

At the same time, inclusion of herbs and spices is seen as something that can potentially increase the saltines and general flavor perception, which in turn leads to a significant increase in the overall liking of the product (Ghawi et al., 2014). This is a valuable observation and strategy to pursue, since this is a product that has some garlic and chili in it, but it could also kick it up a notch by playing out with some other spices and herbs, if acceptability is desired to be higher among consumers. Still, according to Ghawi et al. (2014), these ingredients or compounds should be chosen wisely, as they should complement the food, rather than polarize consumers by changing its flavor dramatically.

6. CONCLUSIONS AND RECOMMENDATIONS

Note by note is a molecular gastronomy technique that allows to recreate of come up with new recipes that use pure compounds, or a mixture of compounds, opening up a myriad of opportunities and dishes. This is a tool that fosters creativity and targets very specific needs, such as the overpopulation and the food risks that come with it. By exploiting this, we can take a step forward into the right direction, if done well.

This report shows the recipe and final result of a tomato soup with potatoes, that started off from this note by note principle. As a dish that is split in two, the product ended up being tried all together, and showed to achieve in a general consumer consensus, high levels of liking and acceptability for its appearance, texture, flavor and aftertaste. The color was generally appreciated, as well as its semi-liquid texture that can be felt both, outside and inside the mouth. The flavor was well balanced for the soup, and slightly acid for the potatoes.

It is also an attractive option if this a product that aims to be sold at restaurants, because producing it costs only €2.44 euro, without taking its storage into account. This opens up the door to further innovation without sacrificing its profitability in the short and long run.

Still, this is not a product without its areas of improvement. Based on the literature review, and the sensory analysis, some recommendations can be made in order to exploit the versatility of this technique, the dish itself, and its possibilities. So, if it is desired to explore more, these are some of the options than can be followed:

- To try to improve the product by generating different versions of the same idea. It has been found that, for the soup, adding herbs and spices the acceptability can be significantly increased. And for the potatoes, the citric acid could also be reduced a little bit.
- A sensory analysis that also measures quantitative data could extract much more information and could be used along with the qualitative information that has already been obtained. This would, as a result, lead to more objective conclusions
- To taste the product the way it is supposed to be eaten. With bread, cheese, or even with wine. It has been observed that people associate these kinds of products as part of a bigger picture or experience. This could also provide insightful data.

7. REFERENCES

Askew, K., 2017. Population growth 'a threat to food quality'. *foodnavigator.com*. Available at: https://www.foodnavigator.com/Article/2017/11/10/Population-growth-a-threat-to-food-quality#:~:text=Global%20population%20growth%20means%20that,reaches%209.1bn%20by%202050. [Accessed April 18, 2022].

Burke, R., This, H. & Kelly, A.L., 2016. Molecular gastronomy. *Reference Module in Food Science.*

Cocineros. 2022. Maltodextrina (500g), Sosa. [ONLINE] Available at: https://www.cocineros.info/maltodextrina-en-polvo. [Accessed 30 April 2022].

Cocineros. 2022. Pectina 325 NH 95 (500g), Sosa. [ONLINE] Available at: https://www.cocineros.info/pectina-325-nh-95-500g-sosa. [Accessed 30 April 2022].

Conaty. 2022. Schwartz Ground White Pepper 425g. [ONLINE] Available at: https://www.conatycatering.com/ambient-food?product_id=57721. [Accessed 30 April 2022].

EFSA. 2017. Re-evaluation of xanthan gum (E 415) as a food additive. [ONLINE] Available at: https://efsa.onlinelibrary.wiley.com/doi/full/10.2903/j.efsa.2017.4909. [Accessed 30 April 2022].

European Parliament & Council (2008). No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives (Text with EEA relevance) OJ L 354, 31.12.2008, p. 16–33 (BG, ES, CS, DA, DE, ET, EL, EN, FR, GA, IT, LV, LT, HU, MT, NL, PL, PT, RO, SK, SL, FI, SV) Special edition in Croatian: Chapter 13 Volume 034 P. 67 - 84

European Parliament & Council (2008). No 1334/2008 of the European Parliament and of the Council of 16 December 2008 on flavourings and certain food ingredients with flavouring properties for use in and on foods and amending Council Regulation (EEC) No 1601/91, Regulations (EC) No 2232/96 and (EC) No 110/2008 and Directive 2000/13/EC.

European Parliament & Council (2010). Regulation (EU) No 257/2010 of 25 March 2010 setting up a programme for the re-evaluation of approved food additives in accordance with Regulation (EC) No 1333/2008 of the European Parliament and of the Council on food additives.

FAO, 2021. The state of food security and Nutrition in the world 2021. *www.fao.org*. Available at: https://www.fao.org/state-of-food-security-nutrition [Accessed April 18, 2022].

FSAI, 2012. Guidance on Flavourings. *Food Safety Authority of Ireland*, [Online]. 1, 12-14. Available at: https://www.fsai.ie [Accessed 30 April 2022].

Ghawi, S.K., Rowland, I. & Methven, L., 2014. Enhancing consumer liking of low salt tomato soup over repeated exposure by Herb and spice seasonings. *Appetite*, 81, pp.20–29.

Gourmet Versand. 2022. Acidifier Citric Acid (Acid Citrique), Powder (E330), Louis Francois. [ONLINE] Available at: https://www.gourmet-versand.com/en/article25042/acidifier-citric-acid-acid-citrique-powder-e330-louis-francois-1-kg.html. [Accessed 30 April 2022].

IQEMUSU. 2022. Onium. [ONLINE] Available at: https://iqemusu.com/en/produit/onium-2/. [Accessed 30 April 2022].

Ryoo, J.Y. et al., 2020. An Analysis of Consumers' Internal Perception of Soup and Sauce using ZMET. *The Korean Society of Food Culture*, 35(5), pp.417–425.

Sosa. 2020. Pectins. [ONLINE] Available at: https://www.sosa.cat/wp/wp-content/uploads/Pectines_CAST.pdf. [Accessed 30 April 2022].

Statista, 2021. *Population - Statistics & Facts*. [online] Statista. Available at: https://www.statista.com/topics/776/population/#topicHeader__wrapper [Accessed 18 Apr. 2022].

SuperValu. 2022. Goodall's Yellow Food Colouring (25 ml). [ONLINE] Available at: https://shop.supervalu.ie/shopping/food-cupboard-baking-decorations-goodall-s-yellow-colouring-25-ml-/p-1011501000. [Accessed 30 April 2022].

SuperValu. 2022. SuperValu Table Salt (750 g). [ONLINE] Available at: https://shop.supervalu.ie/shopping/food-cupboard-salt-pepper-supervalu-table-750-g-/p-1037903000. [Accessed 30 April 2022].

SuperValu. 2022. Xanthan Gum (100 g). [ONLINE] Available at: https://shop.supervalu.ie/shopping/health-wellness-gluten-free-bakery-baking-doves-farm-xanthan-gum-100-g-/p-1068950001. [Accessed 30 April 2022].

Tesco. 2022. Knorr Mashed Potato 2X4servings 204G. [ONLINE] Available at: https://www.tesco.ie/groceries/en-IE/products/252151636. [Accessed 30 April 2022].

This, H., 2005. Molecular gastronomy. *Nature Materials*, 4(1), pp.5–7.

This, H., 2009. Molecular gastronomy, a scientific look at cooking. *Accounts of Chemical Research*, 42(5), pp.575–583.

This, H., 2016. What can 'artificial meat' be? Note by note cooking offers a variety of answers. *Notes Académiques de l'Académie d'agriculture de France*, [online] 6. Available at: https://www.researchgate.net/publication/280679407_Note_by_note_cooking [Accessed 18 Apr. 2022].

UN, 2021. Analysing global economic trends and policy - united nations. *United Nations Department of Economic and Social Affairs.* Available at: https://www.un.org/development/desa/dpad/ [Accessed April 18, 2022].

Vanitha, T. & Khan, M., 2020. Role of pectin in food processing and food packaging. *Pectins - Extraction, Purification, Characterization and Applications*.

8. APPENDIX – LOGBOOK

WEEK NO.: 1 **DATE: March/28th/2022**

Weekly Aims and Objectives:

- Define the approximate quantities of the ingredients to be used, and for them to properly emulate the soup and the potatoes
- Evaluate if some changes (in ingredients or recipe) must be done

Materials and Method (Ingredients, Equipment and Method)

Tomato soup	
Ingredients	**Trial 1**
Water	100 mL
Xanthan gum	0.5 grams
Red coloring agent	A pinch*
Black coloring agent	A pinch*
Onium flavor	2 drops
Chili flavor	3 drops
Tomato flavor	6 grams
Carrot flavor	4 grams
Salt	0.5 grams

*Difficult to weigh, used just a tiny bit (one small drop)

Recipe tomato soup:

1.- Weigh all the ingredients.

2.- Mix with a handheld mixer the water with the xanthan gum until well blended.

3.- Add the tomato and carrot flavors and mix well, but not too much or there will be a lot of air bubbles.

4.- Add the onium and chili flavors, along with the salt and mix well.

5.- Lastly, add the coloring agents and mix until the desired color is achieved.

Equipment:

- Handheld mixer, scale, bowl

Potatoes	
Ingredients	**Trial 1**
Water	100 mL
Potato starch	30 grams
Cellulose	2 grams
Yellow coloring agent	A pinch*
Agar-agar	0.5 grams
Salt	0.5 grams

*Difficult to weigh, used just a tiny bit (one small drop)

Recipe potatoes:

1.- Weigh all the ingredients.

2.- Mix with a whisk the water with the potato starch, cellulose and salt.

3.- Add the color and mix well until the color is homogeneous.

4.- Put the product in the stove, and while mixing, add the agar-agar.

5.- Mix well until the product starts to boil and put it into the molds.

6.- Freeze the samples for at least 15 minutes at -15 ºC.

7.- Cut the potatoes into cubes.

Equipment:

- Scale, bowl, whisk, stove, freezer, molds

Results and discussion:

- For the tomato soup:
    - The color achieved was of a very ripe tomato, there is no need to use the black coloring agent, and it might be interesting to see what the soup would like if no coloring agents are used at all. The tomato flavor provides color by itself
    - The texture was okay, not too thick nor liquid, it was easy to grab with a spoon, and it is not hard to swallow. The quantities used for xanthan gum seem to work fine
    - When it comes to the flavor, the balance between tomato and carrot is okay, but the carrot could be a bit more intense. Though the spiciness is nice, some

people find it a bit too strong, which could be the reason why some notes are being masked up / not perceived

- For the potatoes:
    - The color is a little too strong (the yellow looks fake for potatoes), this could be because using just the yellow color might not be enough to find the balance and imitate the appearance of a real potato
    - The potatoes are not very solid, they are kind of solid from the outside, but they are more liquid inside, cutting them was hard. Agar-agar does not seem to be appropriate for this
    - It lacks flavor, it must be increased considerably, maybe by using potato powder that is available in the kitchen

Conclusions

- The tomato soup must be improved to balance the flavors and reduce the spiciness, while maintaining the texture. For the color, a proposal would be to evaluate the use of the tomato flavor also as a coloring agent, because it naturally provides some color to the product, that way there would not be any coloring agent in the soup
- For the potatoes, to switch from agar-agar to a different agent (such as pectin, also present in the potatoes) could be explored. Also, adding potato powder to improve the flavor profile is recommended. For the color, the interaction between such powder with the coloring agent must be explored

Recommendations for following week.

- Evaluate not using coloring agents and less chili for the tomato soup
- Use pectin and potato powder for the potatoes

Ingredients required for the following 2 weeks:

Same as here, but also pectin and potato powder.

WEEK NO.: 2 **DATE: April/25th/2022**

Weekly Aims and Objectives:

- Define the final quantities of the ingredients to be used for them to properly emulate the tomato soup and the potatoes
- Establish if there are some theoretical changes / recommendations that we be further understood in the future

Materials and Method (Ingredients, Equipment and Method)

Tomato soup	
Ingredients	**Trial 2**
Water	200 mL
Xanthan gum	1 grams
Onium flavor	2 drops
White pepper	2 grams
Tomato flavor	12 grams
Salt	2 grams

Recipe tomato soup:

1.- Weigh all the ingredients.

2.- Mix with a handheld mixer the water with the xanthan gum until well blended.

3.- Add the tomato flavor and the white pepper and mix well, but not too much or there will be a lot of air bubbles.

4.- Add the onium, along with the salt and mix well.

Equipment:

- Handheld mixer, scale, bowl

Potatoes	
Ingredients	**Trial 1**
Water	150 mL
Maltodextrin	120 grams
Pectin	4.5 grams

Potato powder	30 grams
Salt	2 grams
White pepper	2 grams
Citric acid	1 gram
Yellow coloring agent	A pinch*

*Difficult to weigh, used just a tiny bit (one small drop)

Recipe potatoes:

1.- Weigh all the ingredients.

2.- Mix with a whisk the maltodextrin, pectin, potato powder, white pepper and salt.

3.- In the stove, slowly add water to the product and the yellow coloring, mix thoroughly for a couple of minutes.

4.- Add the citric acid and continue mixing until the product starts to boil.

5.- Put it into the molds and freeze for at least 15 minutes at around -15 ºC.

6.- Cut the potatoes into cubes.

Equipment:

- Scale, bowl, whisk, stove, freezer, molds

Results and discussion:

- For the tomato soup:
    - The color achieved was of a more natural tomato soup, there is no need to use any coloring agent, because the tomato flavor works well enough to provide such color
    - The texture was okay, similar to what was observed last time, as it is easy to manipulate, and it is not hard to swallow
    - There was no carrot flavor during the practice, hence why there was a need to improvise a little. In order to enrich the flavor, the chili flavor was changed to white pepper and the amount of salt was increased by 100%, which ended up providing a more rounded experience overall. The balance in general is okay and the spiciness is better, this time the notes are not being masked up / perceived

- For the potatoes:
    - The color looks better and is more realistic (there are even some black dots, from the pepper, visible in the product), this could be due to the color used, as well as the potato powder
    - In order to better improve the texture of the potatoes, using pectin (1.5% of the total volume) was proposed, but maltodextrin needed to be used in order to activate it. For such reason, maltodextrin was used (at a 40% of the total volume), and the potato starch was removed from the recipe
    - The potatoes are much more solid. They are easy to manipulate in the stove, as well as after they freeze. Cutting them is, though not as cutting actual potatoes, easier to do as in the previous week. When biting the product, it is slightly harder than a regular potato, but has a more similar experience overall
    - The flavor is richer, due to the potato powder. The spiciness was reduced considerably. Citric acid was proposed to give a more “realistic” feel to the product, but it was a bit too acid with the amount that was used

Conclusions

- The tomato soup improved its overall flavor by reducing the spiciness and by changing its source (white pepper). For the color, using only the tomato flavor proved to be a good idea
- For the potatoes, switching from agar-agar to pectic was successful, and the product showed to be more stable and ease to handle, also the texture experience in the mouth was improved considerably. Also, adding potato powder increased the general flavor, which was also improved by the pepper. For the color, the interaction between such powder with the coloring agent was good, and the pepper gave an unexpected good look, making it more appealing to the eye
- Lastly, the use of citric acid in the potatoes is interesting, but if changes were to be made in the future, maybe it could be used at a smaller quantity