Note-by-Note & Food Waste

4-element savory dish with ingredients from food waste

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Introduction

According to the Food Waste Index Report 2021, 17% of food production is wasted worldwide. In homes, 61% of this waste is produced; 26% comes from restaurants and food service, and 13% from retail and convenience stores (United Nations Environment Programme, 2021).

The Waste and Resources Action Program (WRAP) reports that restaurants are not completely involved in tackling food waste. Incorrect storage, improper handling of food products, excessive portions, and leftovers on plates are some of the causes of waste in the food service sector (Sakaguchi, et al., 2018). Therefore, it is therefore important to raise awareness in this sector in order to solve this problem.

Fruits and vegetables have the highest percentage of waste among all food types, with 21.6% (Dalal, et al., 2020). Global fruit production reached over one billion tons in 2017, generating large amounts of by-products and residues. Fruit injuries, bruising, and over-ripening are some of the reasons for the waste (Lucarini, et al., 2021).

In addition to the loss of edible food, wasted fruits and vegetables also result in the loss of labor, energy, chemicals used as fertilizers, land, water, and bioactive components (Dalal, et al., 2020).

The fruit and vegetable processing sector produces large quantities of by-products such as peels, seeds, and rinds (Basri, et al., 2021). These by-products can be used to obtain pigments, fibers, organic acids, phenols, antioxidants, and other molecules of interest (Dalal, et al., 2020).

Pectin is a polysaccharide used as a stabilizer and gelling agent for food applications such as beverages, jams, and jellies. It can be extracted by chemical or enzymatic methods from fruit peels. (Venkatanagaraju, et al., 2019).

Methylcellulose is a polysaccharide that forms gels when heated. This ingredient comes from cellulose found in plants, wood, fruits, and vegetables. For example, cellulose is found in apples and carrots (Choudhury, et al., 2022).

Based on the statistics presented above, this work consists of the creation of a savory dish with four elements using pectin and methyl cellulose as ingredients with the aim of raising awareness of the importance of the problem of food waste in the food service sector.

The four elements were designed using the note-by-note technique used in molecular gastronomy.

Aim and Objectives

Aim

To develop a note-by-note savory dish of four elements using ingredients obtained from fruits and vegetable by-products.

Specific Objectives

1. Conduct bibliographic research on pure compounds and by-product molecules to apply in a savory recipe.
2. Design, test, and set final formulae of a cheese sauce, tomato sauce, spaghetti, and tuile applying pure compounds and by-product molecules.
3. Set up the conditions for preparing the recipe in a kitchen environment using knowledge of molecular gastronomy.
4. Design the dish plating.

Materials and Methods

Table 1 shows the formulation of the cheese sauce. This sauce is formulated with methylcellulose and other ingredients such as lactose, whey and casein protein, starch, oil, and flavors. The cooking process is described in Figure 1.

Table 1. Cheese sauce formula.

INGREDIENT	PURE COMPOUND	g	Supplier
Water	H2O	271.50	
Canola oil	α-linolenic acid (6-14%) Oleic acid (50-65%) Saturated fatty acids (7%)	100.00	
Lactose	Glucose Galactose	30.00	MSK
Whey protein	β-lactoglobulin α-lactalbumin Bovine Serum Albumin Glycomacropeptide	25.00	BP

	Immunoglobulins		
Casein protein	α-casein β-casein κ-casein	25.00	BP
Starch	Amylose (20-30%) Amylopectin (70-80%)	25.00	Gem
Lecithin	Phosporic acid Cholines Esters of glycerol Fatty acids	5.00	MSK
Salt	NaCl	5.00	
Albumin	Albumin	5.00	SOSA
Natural aroma gouda cheese	Diacetyl 2-and 3-methylbutanal 2-methylpropanal Acetic acid Butyric acid	5.00	SOSA
Sodium citrate	Sodium citrate	2.50	MSK
Cheddar flavour	Acetic acid Butyric acid Caproic acid Caprylie acid	1.50	MSK
Methylcellulose	Methyl ether of β-D-glucose chains	1.00	Sosa
Lactic acid	Lactic acid	0.30	MSK

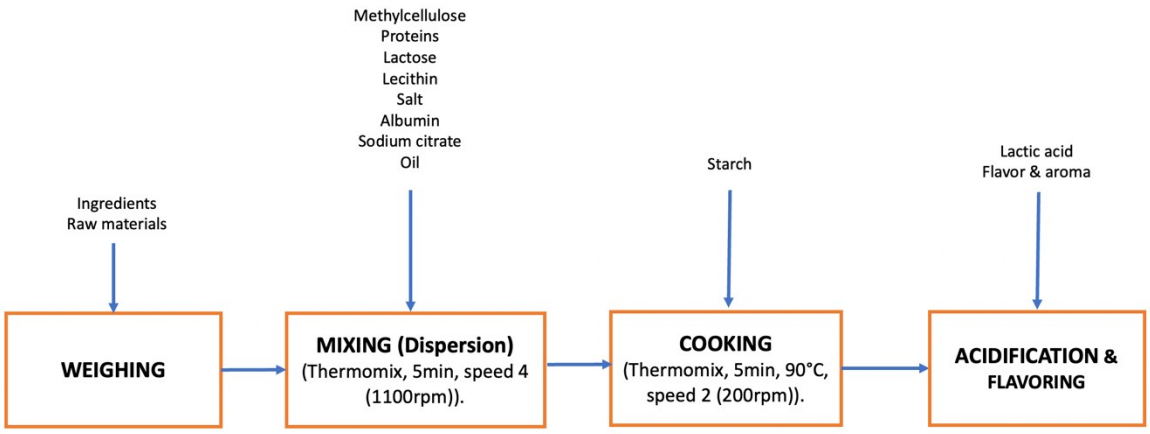

Figure 1. Production process, cheese sauce.

Table 2 shows the formulation of the tomato sauce. This sauce is formulated with pectin, methylcellulose, and other ingredients such as sucrose, spices, and tomato powder. The cooking process is described in Figure 2.

Table 2. Tomato sauce formula.

INGREDIENT	PURE COMPOUND	g	Supplier
Water	H2O	408.5	
Tomato powder	Glucose Fructose Citric acid Malic acid Glutamic acid 2-methoxyphenol Lycopene	37.5	SOSA
Sucrose	Glucose Fructose	20	
Olive oil	Tryglicerides Free fatty acids	15	
High Methoxyl Pectin	Methyl esters of polygalacturonic acid	5	SOSA
Salt	NaCl	5	
Onion powder	Allicin	1	Schwartz
Oregano powder	Carvacrol	1	Schwartz
Basil powder	Estragole	1	Schwartz
Methylcellulose	Methyl ether of β-D-glucose chains	0.5	SOSA
Black pepper powder	Piperine	0.5	Schwartz

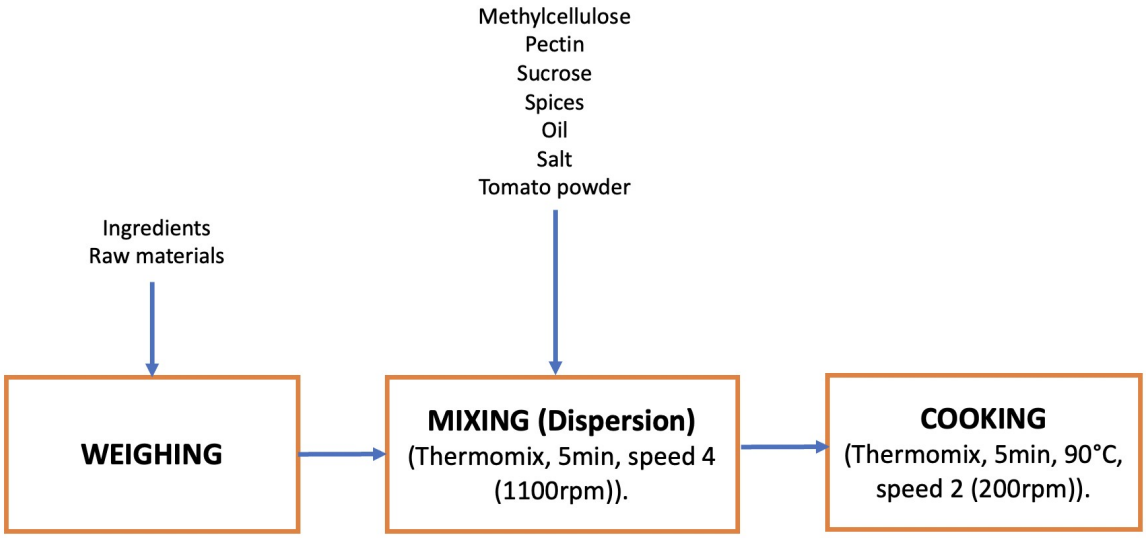

Figure 2. Production process, tomato sauce.

Table 3 shows the formulation of carrot spaghetti, whose main ingredient is agar-agar. Figure 3 describes the elaboration process.

Table 3. Carrot Spaghetti formula.

INGREDIENT	PURE COMPOUND	g	Supplier
Water	H2O	150	
Carrot powder	Sucrose Glucose Xylose Fructose Cellulose Hemicellulose Ligin Glutamic acid β-carotene	10	SOSA
Agar-agar	Agarose Agaropectin	2.7	SOSA
Salt	NaCl	1	

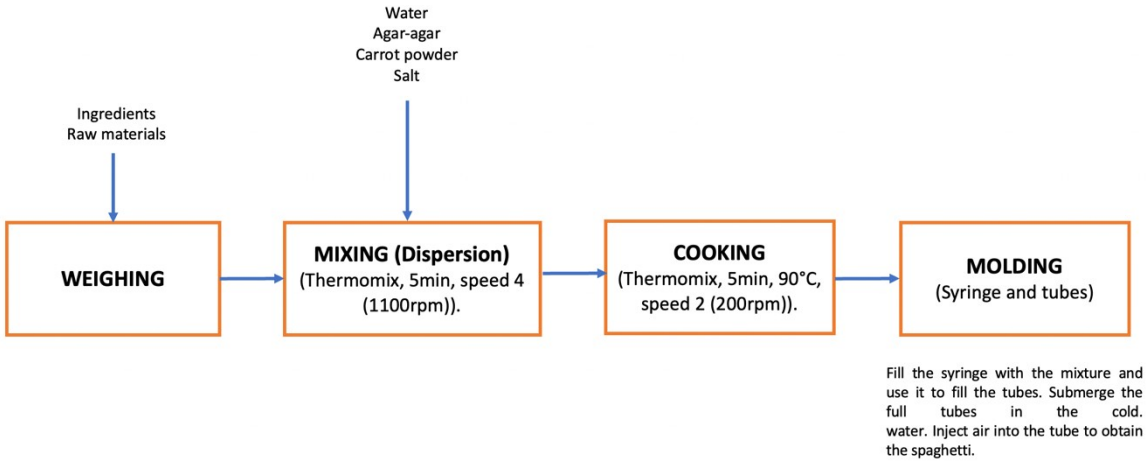

Figure 3. Production process, carrot spaghetti.

The last component of the dish is a tuile. The formulation is shown in Table 4 and the process in

Table 4. Tuile formula.

INGREDIENT	PURE COMPOUND	g	Supplier
Water	H2O	82	
Starch	Amylose (20-30%) Amylopectin (70-80%)	12	GEM
Gluten	Gluten	3	SPIEGELHAUER
Green colorant	Chlorophyll	0.2	MALLARD FERRIERE

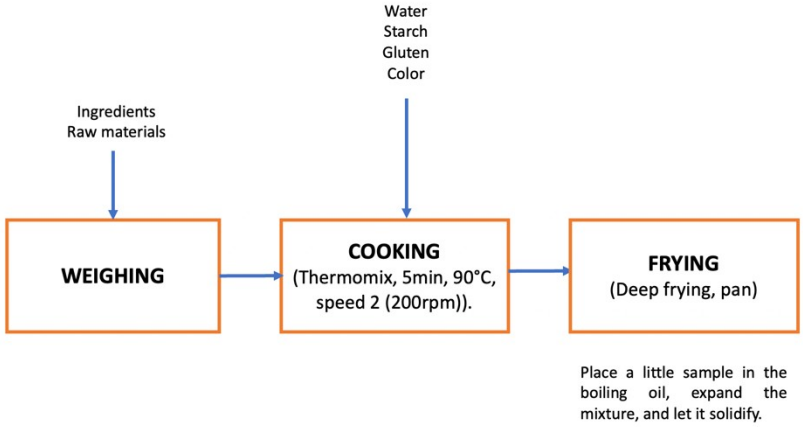

Figure 4. Production process, tuile.

Results

Figure 5. Note-by-note dish with 4 elements.

Figure 6. Note-by-note dish with 4 elements.

The savory dish is constituted of four elements: (i) cheese sauce, (ii) tomato sauce, (iii) carrot spaghetti, and (iv) tuile.

Table 5 summarizes the main physicochemical structure of each element of the dish. A more detailed explanation of the structure is provided in the *discussion section*.

Table 5. Physicochemical structure of the dish.

Element	Main physicochemical structure
Cheese sauce	Emulsion O/W
Tomato sauce	Solid suspension and gel
Carrot spaghetti	Gel
Tuile	Solid foam

Sensorial analysis

No formal sensory evaluation was conducted. However, some sensory descriptors for each element of the dish are shown below.

Table 6. Sensory descriptors.

Element	Main physicochemical structure
Cheese sauce	White color, typical cheese aroma, creamy and thick texture. The cheese flavor could be highlighted more.
Tomato sauce	Red color, typical tomato aroma and flavor similar to Bolognese sauce. The texture is perceived pulpy.
Carrot spaghetti	Transparent orange color, no aroma, solid texture, carrot flavor. The carrot flavor could be highlighted more.
Tuile	No flavor.

Plating

The plating was intended to simulate an island of garbage in the sea. The spaghetti (in the center) represents the island while the tuile (on top of the spaghetti) the garbage. The cheese sauce (small dots on one side) is the white foam formed in the ocean due to all the chemicals and other substances dumped into the water. The tomato sauce represents the increase in ocean temperature.

Although plating has an inspiration in waste in the ocean, it has a correlation with food waste and other residues from the food industry.

According to Power Knot (2021), some food waste is dumped into the ocean, and these products often contain pesticides, hormones, antibiotics, or preservatives. These chemicals bioaccumulate and contaminate the water, affecting marine life and the fishing industry. In addition, food production emits greenhouse gases that increase the temperature of the planet and, therefore, of the oceans. Lastly, some packaging used to preserve food ends up in the ocean if they are not biodegradable. This has

caused the accumulation together with other types of residues the formation of garbage islands in the ocean.

Discussion

Cheese sauce

The cheese sauce can be defined as an emulsion O/W. Table 7 shows the functional properties of each ingredient and which phase of the system they are part of.

Table 7. Functional properties of the ingredients in the cheese sauce.

INGREDIENT	FUNCTIONAL PROPERTY	PHASE
Water	Main constituent of the continuous phase. Dispersion of powders and solvent of polar substances. Proteins interact with water and form water suspensions. (Sołowiej, 2020)	Continuous
Canola oil	Main constituent of the dispersed or discontinuous phase. Texture development and palatability (Sołowiej, 2020).	Dispersed
Lactose	Solids and sweetness contribution (Sołowiej, 2020).	Continuous
Whey protein	Emulsifier and texture development. Above 65°C, whey protein denature and aggregate, increasing the viscosity (Sołowiej, 2020).	Interface & continuous
Casein protein	Emulsifier and texture development. Casein interacts with anionic phosphates, which can cause the unfolding of the proteins, so they function as emulsifiers (Sołowiej, 2020).	Interface & continuous
Starch	Viscosity development and water binding. Helps to prevent syneresis. Amylopectin provides a	Continuous

	smooth texture (Sołowiej, 2020).	
Lecithin	Emulsifier. Helps to prevent phase separation. Surrounds the oil droplets and suspends them in the aqueous phase (Kerry Health and Nutrition Institute, 2021).	Continuous
Salt	Flavor enhancer.	Continuous
Albumin	Texture and palatability improvement (Food Navigator, 2022).	Continuous
Natural aroma gouda cheese	Provides stronger or richer cheese aroma (Sołowiej, 2020).	Continuous
Sodium citrate	Buffering. Increases hydration of casein micelle (Pastorino, et al., 2003).	Continuous
Cheddar flavour	Provides stronger or richer cheese flavour (Sołowiej, 2020).	Dispersed
Methylcellulose	Reversible thermogelation. Provides viscosity and texture improvement (Bakhsh, et al., 2020).	Continuous
Lactic acid	Acidification and flavor development (Sołowiej, 2020).	Continuous

Tomato sauce

The tomato sauce can be defined as a solid suspension and liquid gel. Methylcellulose and HM Pectin help to create the tridimensional matrix trapping the water and solids. Table 8 shows the functional properties of each ingredient.

Table 8. Functional properties of the ingredients in the tomato sauce.

INGREDIENT	FUNCTIONAL PROPERTY	PHASE
Water	Main constituent of the continuous phase. Dispersion of powders and solvent of polar substances (Sołowiej, 2020).	Continuous
Tomato powder	Provides flavor, color, sweetness, and texture. It gives the main sensory characteristics to the sauce.	Solids in a continuous phase

Sucrose	Solids and sweetness contribution.	Continuous
Olive oil	Flavor development.	Dispersed
HM Pectin	Gelling agent (Seshadri, et al., 2003).	Continuous (gel)
Salt	Flavor enhancer.	Continuous
Methylcellulose	Reversible thermogelation. Provides viscosity and texture improvement (Bakhsh, et al., 2020).	Continuous (gel)
Spices	Flavor development.	Continuous

Carrot Spaghetti

The carrot spaghetti can be labeled as a solid gel. Agar-agar is responsible for providing the texture. This hydrocolloid hydrates when hot and forms a solid gel when cooled. Table 9 summarizes the functionality of each component.

Table 9. Functional properties of the ingredients in the spaghetti.

INGREDIENT	FUNCTIONAL PROPERTY	PHASE
Water	Main constituent of the continuous phase. Dispersion of powders and solvent of polar substances (Sołowiej, 2020).	Continuous
Carrot powder	Provides flavor, color, sweetness, and texture. It gives the main sensory characteristics to the sauce.	Solids in a continuous phase
Agar-agar	Agar helps gel, stabilize, texturize, and thicken food applications. To form the gel, the gum must be heated and allowed to cool (Marcus, 2013).	Continuous
Salt	Flavor enhancer.	Continuous.

Tuile

For preparing the tuile, it needs starch and gluten. Table 10 shows the functionality of each ingredient.

Table 10. Functional properties of the ingredients in the tuile.

INGREDIENT	FUNCTIONAL PROPERTY	PHASE
Water	Main constituent of the continuous phase. Dispersion of powders and solvent of polar substances (Sołowiej, 2020).	Continuous
Starch	Viscosity development and water binding (Sołowiej, 2020).	Continuous
Gluten	It gives a firm texture and absorbs twice its weight in water (Pareyt, et al., 2008).	Continuous
Salt	Flavor enhancer.	Continuous.

As can be seen in the information presented above, each ingredient has a function in structuring the elements of the dish. Ingredients manufactured with fruit and vegetable wastes were successfully incorporated into the recipe. The methylcellulose and pectin were responsible for achieving the textures in the sauces.

Sensory analysis was not conducted due to the small quantities produced and the limited time. However, the main descriptors are shown in the results section. It is important to highlight that although the dish tastes good, improvements in the flavoring need to be made to simulate a real culinary dish.

The plating has succeeded in simulating the waste in the sea. The correlation of this concept with food waste is explained in the results section.

Employing the technique note by note proved challenging at first. Nevertheless, understanding the function of each component helped to create the recipes in a simpler way.

Conclusions

A savory dish could be recreated using the note-by-note technique by incorporating ingredients made from fruit and vegetable waste. The plating sought to raise awareness of the role of the food industry in the care of the seas and oceans. Although the elements were well achieved in texture, the flavor could be improved.

For further research, the use of flavor with modifying properties (FMPs) can be explored to boost the flavor. In addition, the substitution of tomato

powder can be developed with the incorporation of colorants, flavorings, and the addition of acids.

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Logbook

Molecular Gastronomy

Note-by-note

Week 1

Student Name: Leonardo Daniel VILLEGAS HERNANDEZ

Date: March 20th, 2023

Objective

To develop a note-by-note savory dish of four elements using ingredients obtained from fruits and vegetable by-products.

Weekly objective

1. Design, test, and set the final formula for a cheese sauce using pure compounds.
2. Test different percentages of starch and methylcellulose.

Materials and methods

Materials

Table 1. Formulae.

INGREDIENT	PURE COMPOUND	FORMULA	
		A (g)	B (g)
Water	H2O	271.50	271.50
Canola oil	α-linolenic acid (6-14%) Oleic acid (50-65%) Saturated fatty acids (7%)	100.00	100.00
Lactose	Glucose Galactose	30.00	30.00
Whey protein	β-lactoglobulin α-lactalbumin Bovine Serum Albumin Glycomacropeptide Immunoglobulins	25.00	25.00
Casein protein	α-casein β-casein κ-casein	25.00	25.00

Starch	**Amylose (20-30%)** **Amylopectin (70-80%)**	**25.00**	**30.00**
Lecithin	Phosporic acid Cholines Esters of glycerol Fatty acids	5.00	5.00
Salt	NaCl	5.00	5.00
Albumin	Albumin	5.00	5.00
Natural aroma gouda cheese	Diacetyl 2-and 3-methylbutanal 2-methylpropanal Acetic acid Butyric acid	5.00	5.00
Sodium citrate	Sodium citrate	2.50	2.50
Cheddar flavour	Acetic acid Butyric acid Caproic acid Caprylie acid	1.50	1.50
Methylcellulose	**Methyl ether of β-D-glucose chains**	**1.00**	**1.5**
Lactic acid	Lactic acid	0.30	0.3

Equipment

- 2 bowls
- 2 wood spoons
- 2 plates
- 2 spoons
- 1 weighing scale
- 1 Thermomix

Process

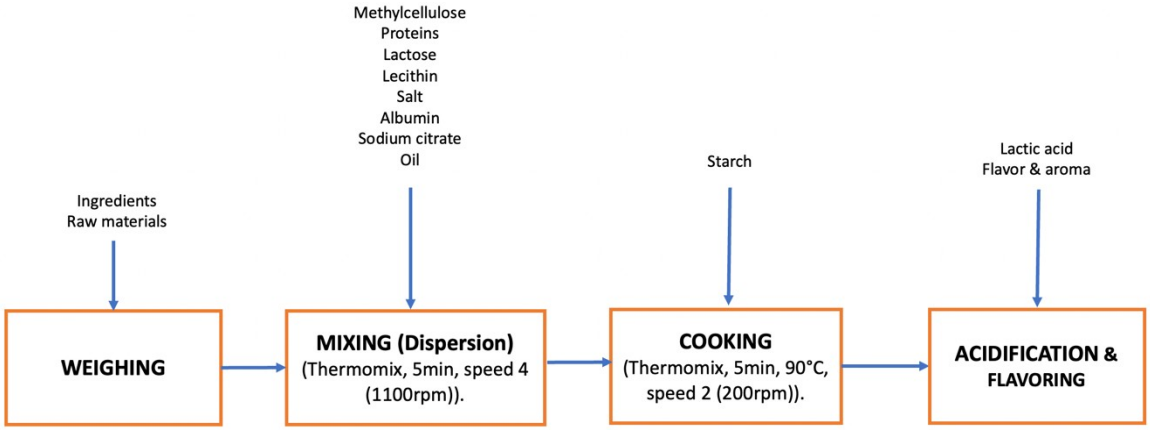


Figure 1. Process.

Results and discussion

Of the two formulations tested, A was the one that developed the best texture as it was thick but fluid. Formula B was much thicker, achieving a more viscous but uncharacteristic consistency.

The final formula had a concentration of 25 g starch and 1.0g methylcellulose.

In sensory terms, both are described with white color, typical cheese aroma, and creamy and thick texture. The cheese flavor could be highlighted more.

Figure 2. Cheese sauce.

Conclusions

Formula A was chosen as the final recipe to be part of the dish. Methylcellulose and starch help to develop a great texture.

Molecular Gastronomy

Note-by-note

Week 2

Student Name: Leonardo Daniel VILLEGAS HERNANDEZ

Date: March 27th, 2023

Objective

To develop a note-by-note savory dish of four elements using ingredients obtained from fruits and vegetable by-products.

Weekly objective

1. Design, test, and set the final formula for a tomato sauce using pure compounds.
2. Test different percentages of pectin and methylcellulose.

Materials and methods

Materials

Table 1. Formulae.

INGREDIENT	PURE COMPOUND	A (g)	B (g)
Water	H2O	408.5	408.5
Tomato powder	Glucose Fructose Citric acid Malic acid Glutamic acid 2-methoxyphenol Lycopene	37.5	37.5
Sucrose	Glucose Fructose	20	20
Olive oil	Tryglicerides Free fatty acids	25	15
High Methoxyl Pectin	**Methyl esters of polygalacturonic acid**	**3**	**5**
Salt	NaCl	5	5
Onion powder	Allicin	1	1
Oregano powder	Carvacrol	1	1
Basil powder	Estragole	1	1
Methylcellulose	**Methyl ether of β-D-glucose chains**	**0.3**	**0.5**

Black pepper powder	Piperine	0.5	0.5

Equipment

- 2 bowls
- 2 wood spoons
- 2 plates
- 2 spoons
- 1 weighing scale
- 1 Thermomix

Process

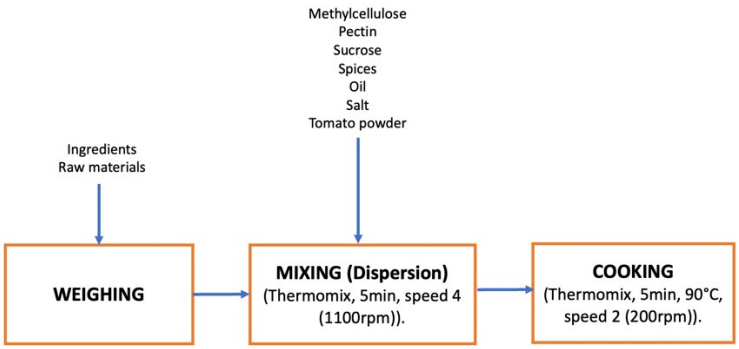
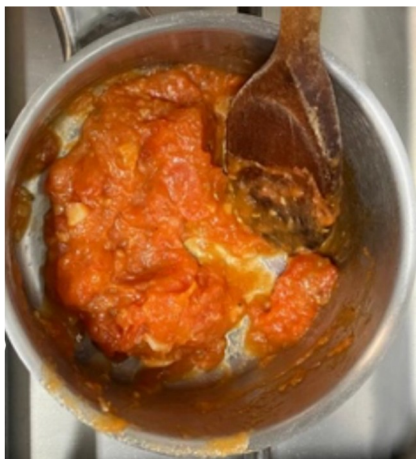


Figure 1. Process.

Results and discussion



Of the two formulas tested, formula B developed the better texture, as it was thick and pulpy. Formula A was more fluid and had a smoother consistency.

The final formula had a concentration of 5g pectin and 0.5g methylcellulose.

In sensory terms, it has a red color, a typical tomato aroma, and a flavor like Bolognese sauce. The texture is perceived as pulpy in formula B

Figure 2. Tomato sauce.

Conclusions

Formula B was chosen as the final recipe to be part of the dish. Methylcellulose and pectin help to develop a great texture when is hot.

Molecular Gastronomy

Note-by-note

Week 3

Student Name: Leonardo Daniel VILLEGAS HERNANDEZ

Date: April 17th, 2023

Objective

To develop a note-by-note savory dish of four elements using ingredients obtained from fruits and vegetable by-products.

Weekly objective

1. Design, test, and set the final formula for a tomato sauce using pure compounds.
2. Design, test, and set the final formula for a tuile using pure compounds

Materials and methods

Materials

Table 1. Formula carrot spaghetti.

INGREDIENT	PURE COMPOUND	g
Water	H2O	150
Carrot powder	Sucrose Glucose Xylose Fructose Cellulose Hemicellulose Ligin Glutamic acid β-carotene	10
Agar-agar	Agarose Agaropectin	2.7
Salt	NaCl	1

Table 2. Formula tuile.

INGREDIENT	PURE COMPOUND	g
Water	H2O	82

Starch	Amylose (20-30%) Amylopectin (70-80%)	12
Gluten	Gluten	3
Green colorant	Chlorophyll	0.2

Equipment

- 3 bowls
- 2 wood spoons
- 2 plates
- 2 spoons
- 1 weighing scale
- 1 Thermomix
- 1 frying pan
- 1 syringe
- 1 plastic tube
- Ice

Process

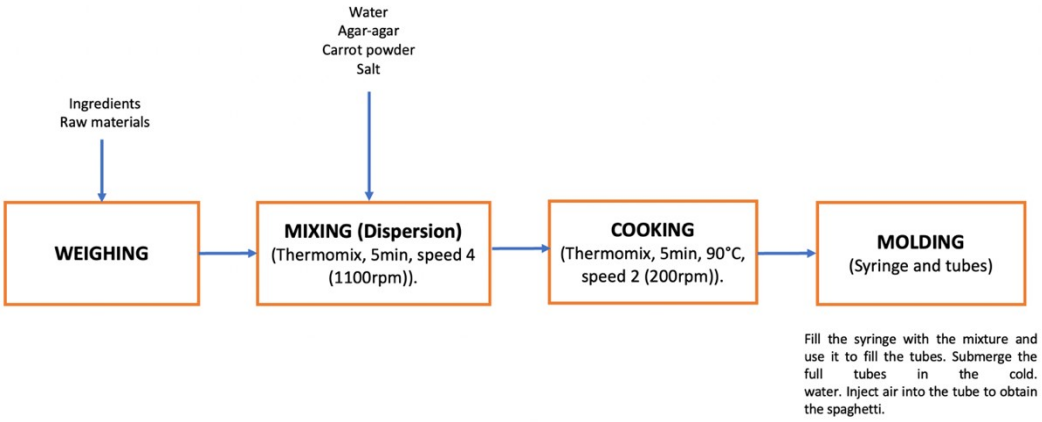


Figure 1. Process, carrot spaghetti.

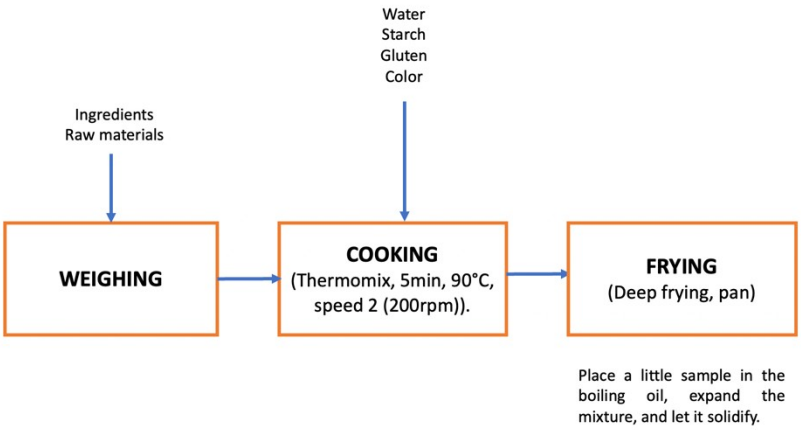


Figure 2. Process, carrot tuile.

Results and discussion

The formation of the noodles was simple. The agar-agar helped provide a solid texture when it cooled.

In sensory terms, the spaghetti has a transparent orange color, no aroma, solid texture, and carrot flavor. However, the carrot flavor could be highlighted more.

The process of creating the tuile was quick, as it was only a matter of hydrating the ingredients and frying the mixture. An important factor to create the desired shape is to spread the mixture well in the hot oil and be careful not to burn them. In sensory terms, it has no flavor; however, for further research is encouraged to flavor it.

Conclusions

Both formulas were validated. Therefore, all the elements of the dish are validated using the note-by-note technique.

Molecular Gastronomy

Note-by-note

Week 4

Student Name: Leonardo Daniel VILLEGAS HERNANDEZ

Date: April 21th, 2023

Objective

To develop a note-by-note savory dish of four elements using ingredients obtained from fruits and vegetable by-products.

Weekly objective

1. Replicate the previously validated formulas.
2. Design the dish plating.

Results

The plating was intended to simulate an island of garbage in the sea. The spaghetti (in the center) represents the island while the tuile (on top of the spaghetti) the garbage. The cheese sauce (small dots on one side) is the white foam formed in the ocean due to all the chemicals and other substances dumped into the water. The tomato sauce represents the increase in ocean temperature.