ADVANCED MOLECULAR GASTRONOMY

FINAL REPORT

RECONSTRUCTED NATURAL: FUTURE OF THE FOOD

SUBMITTED BY:

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ADVANCED MOLECULAR GASTRONOMY
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1. Introduction

“Food science and the art of the chef”, this is how Molecular Gastronomy can be defined, a relatively new scientific discipline that analyzes the mechanism phenomena that occurs during a dish preparation and consumption. Within this discipline the changes of food and its consequences on the experience around cooking and tasting are studied by covering the scientific exploration of culinary definitions, the rigorous testing of culinary precisions and the scientific exploration of the artistic and social aspects of cooking. (Burke, et al., 2016) (This, 2013). Applying this discipline would help to go deep into the science behind any food preparation technique that may be used in a domestic cooking or restaurant environment and understand how the available ingredients can produce the best possible result. The science of molecular gastronomy aim to provide the necessary tools not only to produce finest dishes but also to understand the minimum set of conditions that are required in a dish to be enjoyable and how these conditions can be met, through the modification of raw materials, cooking techniques and presentation of food (Barham, et al., 2010)

One of the applications of gastronomy molecular is note by note cooking, introduced by Herve This in 1994. As the creator defines, this type of cuisine is the next culinary trend, which consists of creating dishes by not using meat, fish, vegetable or fruits but instead using compounds, either pure compounds or mixtures of compounds (This, 2013). This, compares Note by Note cuisine with electronic music, in which different pure waves are mixed to create a complete sound and therefore music. As thousands of new songs have been created using electronic music, note by note cooking have the potential to create 1,000 to the power of 10 new recipes, which represents an enormous number of new opportunities in the modern gastronomy world (Burke & Danaher, 2016)

When discussing important terms related to Molecular Gastronomy and Note by Note cuisine, it is important to mention Molecular Cuisine, a style of cooking that is based on using new tools and techniques, known as Molecular Cooking, to develop new culinary applications (Lavelle, et al., 2021). In this scenario, cooking techniques involving gelling, emulsion and foams can be introduced using also devices and materials found in a chemistry laboratory such as rotary evaporators, ultrasound probes, liquid hydrogen, separating funnels, filter pumps, etc. (This & DeBevoise, 2014).

When contemplating how all these concepts and new applications can be utilized to become relevant in today's situations, the idea of food for the future appears. The global food system is facing important challenges that are threatening food security and environmental sustainability. Population growth, climate change, and resource scarcity are among these issues. Specifically, current dietary patterns are shifting toward more resource-intensive options, which require greater land and water use. For instance, in 2019, greenhouse gas emissions from agrifood systems, including agricultural activities, land use changes, and pre- and post-food production processes, accounted for 31% of global emissions (Sousa, et al., 2024). In this context, Note by Note presents a potential solution by enabling the production of sustainable, nutritious, and customizable foods. By utilizing pure compounds, this approach can reduce reliance on traditional agriculture, minimize food waste, and provide specific dietary needs, aligning with the goals of food security and environmental sustainability.

As mentioned before, the main current dietary demands are placing significant demand for land and water resources. One such trend is the preference for products made with natural ingredients. By definition, which remains ambiguous, as there is no universally accepted standard, a natural ingredient is the one obtained by physical extraction processes without altering its fundamental constituents.

Due to the growing demand for natural products, companies are often focused on traditional extraction methods to maintain the "natural" label. However, there are many ways to obtain the same or similar compounds through alternative processes that do not always meet the criteria to being considered natural. This is the case of vanillin, which can be synthesized from kraft lignin, a by-product of the paper industry, with a substantial environmental benefit. Kraft lignin production of vanillin, which is classified as not natural, is shown to reduce smog formation and CO_2 emissions from non-energy sources to negligible levels (McCallum, et al., 2021). Although it is necessary to clarify that vanilla is different from vanillin, the latter can be used to give the characteristic sweet, creamy, and woody notes that people associate with vanilla, in an artificial manner.

The dish created in this project aimed to highlight how Note by Note cuisine can work towards the food for the future by challenging one important aspect: "Synthetic ≠ Fake". Note by note can use compounds that are catalogued as synthetic, and sometimes synthetic is perceived as inferior. With this dish, the goal was to evoke a natural feeling without having 100% all the ingredients naturally sourced. With this reinforce the idea that synthetic is not necessarily bad. The potential of Note by Note cuisine relies on creating authentic culinary experiences, emphasizing that the essence of food lies in the sensory and emotional responses it evokes.

2. Aim of the Assignment

The aim of this assignment was to develop an innovative dish that aligns with the theme of the 13th International Note by Note Cuisine Contest: Food for the Future. The dish requires scientific knowledge from molecular cooking using the Note-by-Note cuisine.

In this particular dish, the objective was to design a dish that highlights how synthetic compounds can reproduce the sensory qualities of natural foods, without relying on conventional agricultural ingredients. The dish aimed to challenge the negative perception of synthetic ingredients, which can have the potential to reduce environmental impact for the food in the future.

Therefore, three main goals were met:

- Integrate molecular cuisine concepts in the final dish.
- Apply the principles of Note by Note cuisine using pure compounds.
- Create a dish that is reproducible and capable of evoking a natural, comforting sensory experience.

3. Final Materials and Methods

3.1. Materials

The following materials and formulas were used to create the final dish.

Figure 1. *Chemical compounds selected for the formulation of the final dish.*

Table 1. *Chemical compounds selected for the formulation of the final dish.*

Compound		Supplier
1	Taste color freeze-dried passion fruit powder	Sosa
2	Taste color freeze-dried mango powder	Sosa
3	Citric Acid	Louis Francois
4	Xathan Gum	Sosa
5	Citras (Sodium Citrate)	BidFood Iberia
6	Ultrawhip	MSK
7	Pectin	Sosa
8	Peta Crispy	Sosa

Table 2. *Formula and compounds for Passion Fruit Syrup*

Compound	Percentage (%)
Passion Fruit Powder	44,24
Sugar	25,16
Citric Acid	1,84
Xanthan Gum	0,92
Citras (Sodium citrate)	1,84
Water	44,24
TOTAL	100,00

Table 3. *Formula and ingredients for Passion Fruit Shell*

Compound	Percentage (%)
Sugar	34,00
Passion Fruit Powder	15,00
Citric Acid	0,50
Pectin	5,50
Water	45,00
TOTAL	100,00

Table 4. *Formula and ingredients for Mango Shell*

Compound	Percentage (%)
Sugar	34,00
Mango Powder	15,00
Citric Acid	0,50
Pectin	5,50
Water	45,00
TOTAL	100,00

Table 5. *Formula and ingredients for Passion Fruit Foam*

Compound	Percentage (%)
Passion Fruit Powder	15,00
Sugar	12,00
Citric Acid	0,30
MSK Ultrawhip (chicory root fiber, methylcellulose, xanthan gum)	5,00
Water	67,40
TOTAL	100,00

Table 6. *Formula and ingredients for Passion Fruit Juice*

Compound	Percentage (%)
Passion Fruit Syrup	35,17
Water	64,83
TOTAL	100,00

3.2. Methods

The following methods were used to build the final dish:

3.2.1. Syrup & Juice Preparation

To assemble the final dish, a total of 100 g of juice and syrup was prepared.

1. All dry ingredients were combined in a bowl.
2. The specified amount of water was gradually added.
3. The mixture was stirred until a homogeneous syrup was obtained.
4. A portion of the syrup was reserved for final plating.
5. The remaining syrup was transferred to a sealable container suitable for shaking.
6. The required amount of water was added according to the formula, and the container was shaken until fully incorporated.
7. Both the syrup and the juice were set aside for the final assembly of the dish.

3.2.2. Shell Preparation (60 g in total)

To assemble the final dish, a total of 70 g of mixture to create the shell was prepared.

1. All dry ingredients were combined in a pot.

2. The specified amount of water was added, and the mixture was immediately placed over heat.
3. The mixture was brought to a boil while stirring constantly to avoid burning.
4. 15 g of the hot mixture was poured into each compartment of a silicone sphere mold.
5. The mold was refrigerated for 15 minutes.
6. After chilling, the shells were removed from the fridge, demolded, and set aside for final assembly.

3.2.3. Foam Preparation (250 g in total)

To assemble the final dish, a total of 250 of the mixture to foam was prepared.

1. All dry ingredients were mixed in a bowl.
2. The specified amount of water was added.
3. The mixture was stirred until homogeneous, ensuring no lumps remained that could clog the siphon.
4. The mixture was poured into an iSi siphon.
5. One N_2O cartridge was used for a small unit, or two cartridges for a large unit.
6. The siphon was shaken 15–20 times to fully incorporate the gas into the mixture.
7. The siphon was stored in the refrigerator until the final assembly of the dish.

The following outlines the general methodology used in the creation of the dish. The process began with the preparation of core compounds, followed by mixing and hydration to create the syrup. From this syrup, water was added and the mixture shaken in a sealed container to obtain the juice. This procedure was repeated for the other elements of the dish, preparing the syrup according to the formulas presented in the previous tables. Modifications were then made by adding pectin to form the shell and MSK Ultrawhip to produce the foam, using a silicone mold and an iSi siphon, respectively.

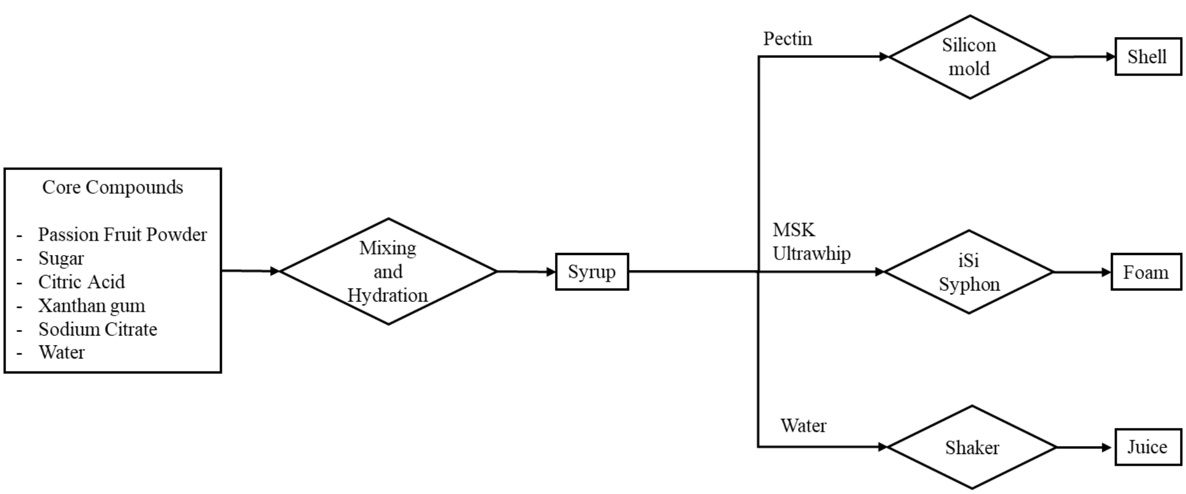

Figure 2. *General methodology implemented to create the different elements of the final dish.*

3.3. Sensory Evaluation

To evaluate the final dish, a sensory evaluation was conducted. The following table summarizes the questions used.

***Table** 7. Questions used for the final dish.*

Question		**Scale / Options**
How would you describe the dish?		Very Artificial – Somewhat Artificial – Neutral – Somewhat Natural – Very Natural
Overall Acceptance	How much do you like the overall appearance?	5 points Hedonic Scale: (DISLIKE EXTREMELY / DISLIKE SLIGHTLY / NEITHER LIKE nor DISLIKE / LIKE SLIGHTLY / LIKE EXTREMELY)
	How much do you like the overall flavor?	
	How much do you like the overall texture?	
	How much do you like the overall aroma?	
	How much do you like the dish overall?	

4. Results

4.1. Final Dish

Reconstructed Natural

Figure 3. *Final dish*

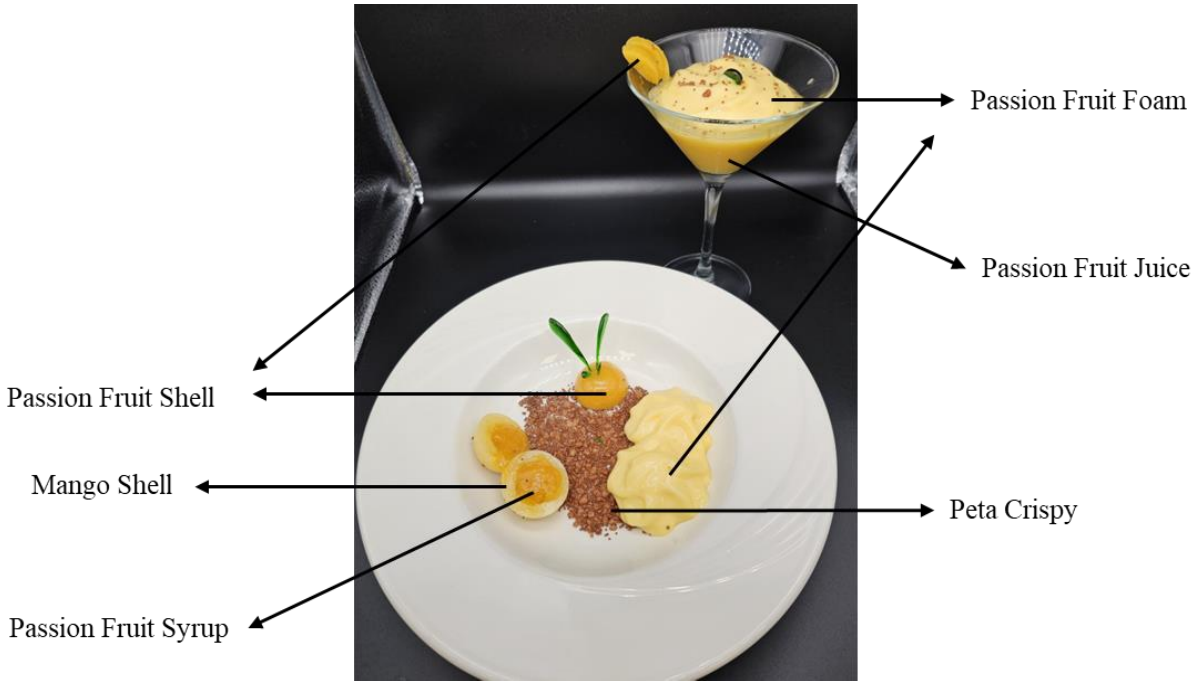

Figure 4. *Elements of the Final Dish*

For the final dish, a deep soup-style plate was used. First, the Crispy Peta base was placed at the bottom of the plate. On top of this, mango and passion fruit shells were arranged. For the mango shells, a small cavity was made on the flat side of each sphere to insert the passion fruit syrup. A caramel decoration (made from sugar, water, and food coloring) was placed on top of the passion fruit shell. Additionally, passion fruit foam was added to the right side of the plate.

A complementary cocktail was also served to highlight the passion fruit juice. The cocktail consisted of a base layer of passion fruit juice, topped with passion fruit foam. Two slices of the passion fruit shell were placed on the side as garnish, and a touch of green caramel was added on top as a final decorative element.

4.2. Sensory Results

In total, eight individuals participated in the final sensory evaluation. The following charts present the results for each question included in the evaluation.

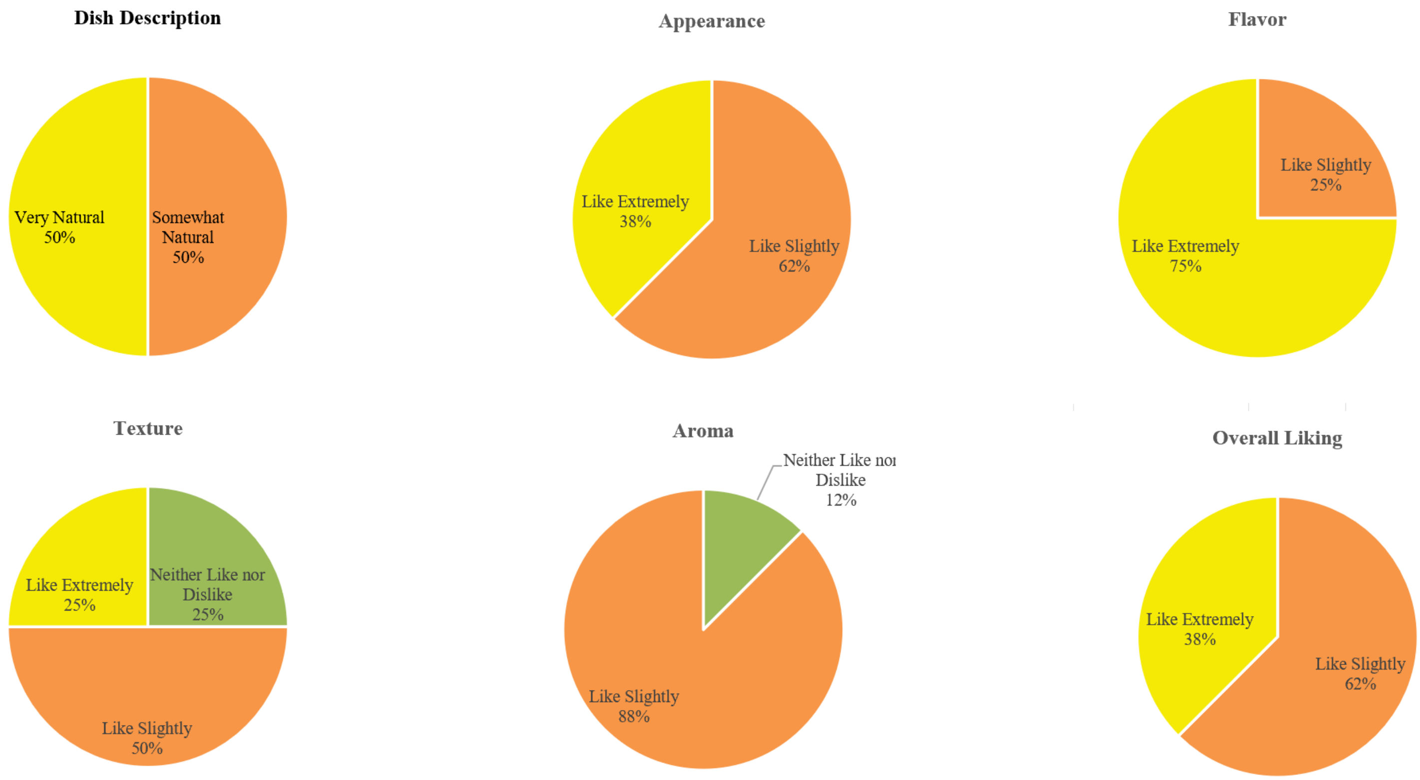

Figure 5. *Charts with the final results of the sensory evaluation*

5. Discussion

5.1. Regulatory Compliance of Ingredients

The formulation of the dish strictly adheres to the European Union (EU) regulations. Specifically, it is under compliance with Regulation (EC) No 1333/2008 on food additives, which defines the accepted additives and the maximum permitted levels.

- Pectin (E440): Used as a gelling agent in the shell component, this additive is authorized under regulation. The EFSA has evaluated pectin and defines that it poses no safety concern at the levels used in food applications (EFSA, 2017)
- Citric Acid (E330): Employed to adjust acidity and enhance flavor, citric acid is permitted under the same regulation.
- Sodium Citrate (E331): Used as a buffering agent in the syrup and juice, sodium citrate is also approved under regulation.
- Xanthan Gum (E415): Incorporated to modify texture of the juice, this additive is authorized for use in various food products.
- MSK Ultrawhip: Containing chicory root fiber, methylcellulose, and xanthan gum, was used to create the passion fruit foam. Each component is individually recognized as safe and permitted under EU regulation.

All additives were used within the "quantum satis" according to the regulation, which means that they were applied at the minimum level necessary to achieve the desired technological effect. No specific thresholds are defined for the compounds used in the final dish.

5.2. Scientific Analysis of Molecular Cooking Techniques

The final dish employed advanced molecular cooking techniques to achieve the final textures and sensory experiences. This includes gelling, for the syrup and shell, and foaming techniques.

Pectin and xanthan gum were used as gelling agents to modify the final texture of the elements of the dish. Pectin is composed of polysaccharides extracted from cell walls, but mainly from citrus fruits. The gelation method of pectin depends on the degree of esterification. For this dish, a low methoxyl amidated pectin (LMA) was used, as was stated by the supplier SOSA. This type of pectin can form stable gels only when it is in presence with cation like calcium, which forms bonds between the carboxyl groups that are in the pectin (Alinsug, et al., 2024). As shown in the following picture, a type of “egg-box” is created which represents the gelling method of LM pectin.

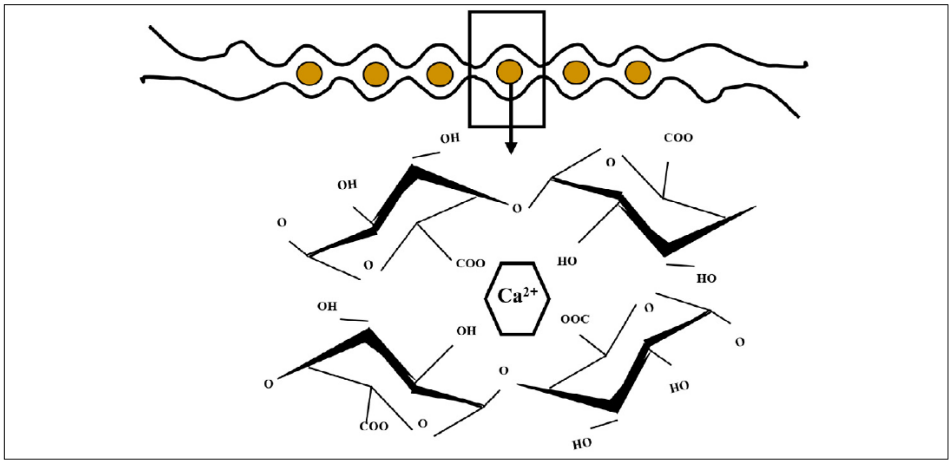

Figure 6. *LM pectin gelation by calcium ions (Alinsug, et al., 2024)*

In this scenario, the supplier SOSA includes the necessary ions required to create gel formation, as it offers fruit pectin with salt and calcium. In addition, and also especially important, LM pectin requires a low pH to be able to form a gel. At lower pH levels, the carboxyl groups of the LM pectin can reduce their negative charge which minimizes electrostatic repulsion between pectin chains, allowing them to stick together and be linked by calcium ions, forming a stable gel network. In the preparation of the dish, the pH was not measured, however, through trial and error, the natural acidity of passion fruit and mango, combined with the addition of citric acid, achieved a sufficiently low pH to form the desired gel texture.

On the other hand, xanthan gum was used as a gelling agent to give the desired texture to the final juice, a crucial element of the final dish. This component is a high molecular polysaccharide with the ability to hydrate immediately in cold water, and it is stable in a wide range of pH, from 2.5 to 11. Xanthan gum exhibits very high viscosities at low shear rates only by using small concentrations such as 0.01% (Fallourd & Viscione, 2009). This was an advantage in the creation of the dish, as the goal was not only to give a natural appearance to the passion fruit juice but also to deliver a natural taste, which is enhanced by a creamy texture. Xanthan gum made it easy to achieve the desired consistency using only the specified dosage.

Finally, the foaming element was prepared using MSK Ultrawhip, a commercial, plant-based foaming agent for use in food products. When blended with a liquid base, in this case the passion fruit powder with citric acid, sugar and water, and charged with nitrous oxide (N_2O) in an iSi siphon, Ultrawhip stabilizes the formation of fine air bubbles, resulting in a light and stable foam (MSK Ingredients, 2025)

5.3. Sensory Evaluation

To evaluate the dish's overall qualities, 8 people answered the sensory evaluation. According to the majority of participants, the dish was "Somewhat Natural," suggesting that the use of artificial ingredients successfully produced a natural appearance. Most answers gave "Like Slightly" to "Like Extremely" ratings for appearance, flavor, texture, and aroma, indicating a generally favorable response. These results imply that the dish was effective in meeting a demand for natural taste and appearance without using 100% natural components.

6. Conclusions

The presented dish successfully demonstrated how note by note, the future trend of the cuisine, have a big potential to contribute to the future of the food. The development of a dish that was innovative, sustainable, and sensorially appealing. By using pure compounds and molecular cooking techniques such as gelling and foaming, the dish recreated appropriate textures and flavors while not using conventional agricultural ingredients.

The dish demonstrated how “synthetic ≠ fake”, making emphasis on how synthetic compounds can deliver pleasant experiences with a lower environmental footprint. The positive answer obtained through the sensory evaluation supports the idea that food that is not 100% natural can still feel natural and comforting.

The future of food must not lose the authentic judgments that the people have about food, involving emotions, culture, and tradition. While science and technology can create extraordinary culinary experiences, the final solution is not to replace food with abstract concepts. People, all of us, are looking always for something that feels familiar, the feeling of tradition. That is why one important solution in the future is to deliver dishes that look, feel, and taste like tradition, also honoring culinary heritage, while at the same time crafting dishes using artificial methods that are more efficient and sustainable. Considering this, note by note can offer in the future the perfect bridge between tradition and innovation.

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