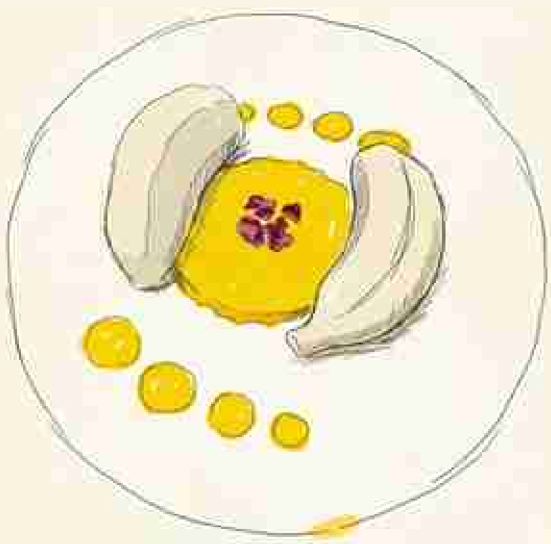
Note by Note



P

# Material and methods

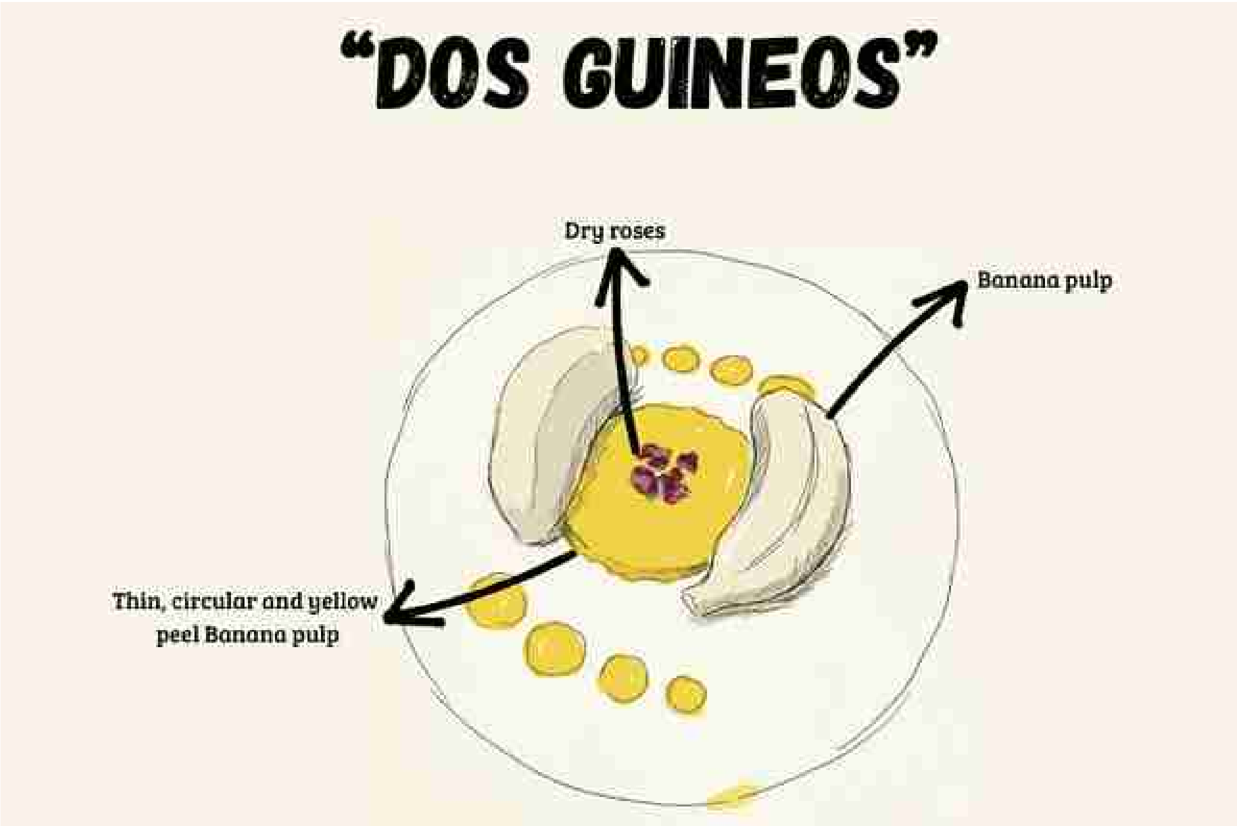



Figure 1 Final dish design

## Materials

Table 1. Ingredients list

| Banana pulp | | | Banana peel | | |
|---|---|---|---|---|---|
| Ingredient | Brand | Percentage | Ingredient | Brand | Percentage |
| Water | N/A | 65% | Water | N/A | 79,4% |
| Potato starch | Family elephant | 15% | Whey isolate | myprotein | 10.8% |
| Edulcorant | splenda | 1% | Sugar | gem | 5.4% |
| Arabic gum | Special ingredients | 0,3% | Cocoa butter | DGF royal | 2.7% |
| Cocoa butter | DGF royal | 0,3% | LM pectin | SOSA | 0.86% |
| Celulose fiber | Nutri Cology | 0,2% | Yellow coloring | Maillard Ferrière | 0.37% |
| Cacao aroma | SOSA | 0,1% | Lecithin | SOSA | 0.22% |

| | | | | | |
|---|---|---|---|---|---|
| Whey protein | myprotein | 0,07% | Calcium chloride | msk | 0.22% |
| Pectin | SOSA | 0,05% | Passionfruit flavouring | Special ingredients | 0.02% |
| | | | Roses flavouring | msk | 0.02% |

Equipment
-Knife
-Cutting board
-Bowls
-Pot
-Rolling pin
-Refrigerator (Brand: COOL HEAD)
-Hand blender (Brand: Robot coupe , Model: mini M.P. 160 V.V.)
-Scale (Brand: Jadever, Model: JWP)
- Stove (Brand: Electrolux, Model: Gas stove - 4 burner - gas oven.

## Methods. Recipe

Banana Pulp
Phase 1 – Hydrate the gum arabic (cold process)
Weigh 30 g of gum arabic.
Weigh 400 g of water (from a total of 618 g to be used later).
Whisk at low speed (avoid creating bubbles).
Let it rest for 30 minutes at room temperature.
Visual check: It should be a liquid gel, with no lumps or specks.

Phase 2 – Prepare the cocoa butter paste with sweetener and whey
Weigh 30 g of cocoa butter.
Weigh sucrose.
Weigh 7 g of whey isolate protein.
Melt the cocoa butter at 40 °C (using a water bath).
Mix the sucrose+ whey (dry blend).
Pour the melted cocoa butter over the dry mixture.
Mix with a spatula until get a thick, smooth, shiny paste.
Phase 3 – Prepare the dry solids
In another dry bowl, weigh:
150 g waxy potato starch
20 g cellulose fiber
5 g pectin
Mix the dry solids well.
Phase 4 – Combine all phases
Take the already hydrated gum arabic (from Phase 1).
Add the remaining cold water:
618 g total – 400 g already used = 218 g cold water.
Add the cocoa butter + sweetener + whey paste (from Phase 2).

Add flavoring and cocoa aroma to taste.
Blend with a hand blender until the paste is completely dissolved.
Phase 5 – Incorporate solids and activate cold thickening
Add the dry solids (from Phase 3) in a rain-like manner, while stirring constantly.
Blend for 2 minutes to ensure the starch is fully hydrated in cold conditions.

Phase 6 – Final heating
Heat the mixture over medium-low heat for approximately 5–8 minutes, until it reaches 75 °C.
Phase 7 – Final texture check
The final texture must be: Thick mass, Heavy, Shiny, Partially releasing from the walls of the pan
Place the batter into the banana-shaped mold

The number of portions for this recipe based on a batch of 400 g. its 11 taking into account that each banana pulp contain approximately 35 g.

Banana Peel
Phase 1 – Hydrate the LM pectin (warm process)
Weigh the sugar and LM pectin.
Weigh the water (from the total water, separated).
Dry-mix the sugar and pectin until uniform.
Heat the water to 40–45°C.
Sprinkle the sugar-pectin mix slowly while whisking gently by hand.
Whisk until slightly viscous and no lumps are visible (2–3 min).
Visual check: Translucent liquid gel, no clumps or granules.

Phase 2 – Hydrate the whey isolate
Weigh the whey isolate.
Weigh the remaining water (from the total).
Heat the water to ~35°C.
Sprinkle the whey slowly while whisking gently.
Whisk until milky and completely smooth.

Phase 3 – Emulsify the fat phase
Weigh the cocoa butter and lecithin.
Melt the cocoa butter gently at low heat (bain-marie).
Stir in the lecithin until homogeneous.

Phase 4 – Combine base mix
Blend Phase 1 and Phase 2 together.
Add Phase 3 while whisking gently.
Add yellow coloring and passionfruit and roses flavoring.
Whisk until uniform and creamy.
Visual check: Even, creamy emulsion, no oil droplets on surface.

Phase 5 – Calcium gelation

Dissolve calcium chloride in the extra water.
Ensure the base mix is at ~35°C.
Pour the calcium solution in a thin stream while whisking vigorously.
Stop whisking as soon as thickening occurs (about 10 seconds).
Visual check: Soft, uniform gel, no liquid separation.

Phase 6 – Molding and setting
Pour immediately into the flat mold.
Cover with plastic film in contact with the surface.
Refrigerate for at least 4 hours.

Assembly procedure
Remove the banana pulp from the mold. Distribute the material along the periphery of a flat circular plate.
From the pre-chilled mold of the banana peel, obtain circular portions. With a flat spatula, transfer each circular portion and position it at the plate's center.
Place rose petals centrally atop the circular portion.

Figure 2 Final ensembled Dish

## Methods. Nutritional calculation Methods

Due to the fact that Nutritics  of the leading platforms for immediate nutritional value calculation does not contain data for the majority of additives used in the product under development (*Nutritics | Food Data Management Software*, 2026), a manual approach was adopted. Caloric content and nutritional information for each ingredient were individually sourced from supplier websites. Approximate values were then calculated based on a 100 g serving and the established recipe percentages.

## Methods. Costing

The costing methodology was established based on ingredient prices provided by TU Dublin for specific bulk quantities. To determine the final price per portion of  35 grams, proportional cost relationships were adapted to the exact amounts utilized in the formulation. Initially, the final percentage of each ingredient within the recipe was calculated. A standardized batch was subsequently prepared using the indicated quantities, and the total mass yield of this production was measured. This total mass was then divided by the target portion size to ascertain the number of portions obtained per batch. Following this, the cost of the specific quantity of each ingredient used in the batch was correlated against the provided TU Dublin unit prices. Finally, the sum of all proportional ingredient costs was divided by the number of portions yielded from the batch, resulting in the precise cost per individual portion.

Regarding the nutritional score, based on the calculations carried out, the product provides 66 kcal per 100 grams. This energy value comes mainly from carbohydrates, in the form of starch, sugar, and Splenda, while protein is supplied exclusively by Whey Protein and the total fat fraction derives from cocoa butter. Additionally, the product contains fiber, contributed by gum arabic, cellulose, and pectins. Although one of the main objectives was to develop a low-calorie banana alternative with a high protein content, this latter goal was not satisfactorily achieved, as the protein percentage remained around 2.5%, which is rather modest for it to be considered a meaningful source of this macronutrient. However, the energy contribution per serving yielded more favorable results. Each regular 35 g serving contains only 23 kcal, which does meet the goal of offering a reduced-calorie product. In fact, when compared to an actual banana in the same amount, the latter would provide around 31 kcal, representing a 25% increase in energy relative to the developed product (Prescott, 1918).

Regarding the production costs, the total for an 11-serving batch was broken down into its two main components. The pulp, prepared from a 400 g batch, had a cost of  0.81 €, which translates to just 0.07 € cents per serving. On the other hand, the peel turned out to be the most significant factor driving up the overall cost. With a batch of 360 g costing 2.32 €, this was largely due to the inclusion of Whey Protein, which alone accounted for 84% of the peel's price. Despite this, the objective of keeping the product affordable was successfully met. The combined cost of pulp and peel worked out to 0.22 € cents per serving, a figure that remains quite convenient from an economic standpoint.

## Flavor, odor & color development

For flavor, odor, and color development, raw cacao flavor was incorporated into the pulp matrix as the principal flavor in this dish. On the other hand, passion fruit flavor was used in the peel. Regarding the latter, passion fruit flavour drop is not a food additive but a flavouring; it has no legal maximum limits under EU Regulation (EC) No 1334/2008, though it must follow Good Manufacturing Practice (GMP), and the manufacturer recommends 0.3%-1.0% for desired taste. This combination exhibits high compatibility due to the passion fruit is dominated by sulfur-containing volatile compounds such as ethyl hexanoate and linalool, alongside high acidity (Narain *et al.*, 2004). Whereas dark cacao contains sharp, fruity, acidic notes derived from acetic, citric, and lactic acids (Santander *et al.*, 2021). Consequently, both matrices share similar volatile aroma compounds. Furthermore, a rose odor was incorporated into the peel. Rose flavour is likewise not a food additive but a flavouring, and under EU Regulation (EC) No 1334/2008 it has no usage limits provided it meets EU safety criteria. Raguso, (2016) demonstrated that adding rose-associated compounds such as linalool and geraniol to passion fruit aroma increases perceived tropical fruit intensity, indicating synergistic olfactory interaction.

In contrast, Banana flavor was deliberately excluded from this flavor and aroma mixture because the initial objective was to retain only its appearance and texture, allowing diners to experience unexpected flavors and odors upon consumption. This decision is further supported by the orthogonal (non-overlapping) nature of their dominant odor profiles: banana's key aroma molecules such as isoamyl acetate, eugenol (Jordán *et al.*, 2001) do not share chemical receptors or volatile binding sites with passion fruit's sulfur-containing esters, leading to perceptual segmentation rather than blend integration.
Regarding color, the pulp's white appearance required no added colorants, as the raw materials naturally mimic banana pulp's aspect, while the peel presented a yellow color, thereby preserving the banana's overall structure and appearance. A natural, oil-soluble yellow colouring from Mallard Ferrière was used. It is derived from safflower (*Carthamus tinctorius*) and lemon. As it consists solely of plant-based ingredients processed by physical means, it is not classified as a food additive under EU Regulation 1333/2008. Therefore, it bears no E-number and is not subject to additive usage limits.

SECTION 06

# Conclusions

A dessert replicating the form and texture of a banana was successfully developed, characterized by a simple assembly process supported by complex food materials science. The formulation required the simultaneous resolution of multiple structural challenges: the engineering of complex multiphase systems, the stabilization of emulsions between immiscible phases, the incorporation of air into the emulsion matrix to modulate texture, and the strategic use of diverse dietary fibers to provide structural integrity. All these elements were arranged with the singular goal of mimicking the rheological properties of banana pulp.

The design process was grounded in the principles of Food materials Structures and technologies. The behavior of constitutive elements was predicted by analyzing the composite food matrix across different observation scales, from the molecular to the macroscopic level.

This predictive structural design was informed by an integrated review of scientific literature and fundamental texts in food science and analysis, allowing for an engineered approach to the product's architecture.

The final product achieved the target economic and nutritional profiles, with a cost of €0.22 per 35g banana and a caloric value of 23 kcal per unit, representing a significant calorie reduction compared to a real banana. Furthermore, a precise sensory equilibrium was attained, encapsulating the representative flavors and aromas of Ecuador's primary export raw materials: banana, cocoa, roses, and passion fruit.

Regarding the replication of the banana peel, the theoretical model predicted a fixed, stable gel-like pulp. However, the initial applied technique proved incorrect, as the resulting product exhibited syneresis. Achieving the exact desired texture for the peel will therefore require further experimental sessions. Key processing parameters must be rigorously controlled, including precise pH measurement to manage the isoelectric point of the proteins, regulation of the calcium chloride concentration for ionic cross-linking within the matrix, fine-tuning of the pectin content, and strict temperature precision.

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NUTRITION FACTS

Serving Size: 100 g

| Nutrient | Amount per 100 g |
|---|---|
| Total Calories | 66 kcal |
| Total Fat | 0.5 g |
| - Saturated Fat | 0.3 g (approx.) |
| - Trans Fat | 0 g |
| Total Carbohydrates | 13.9 g |
| - Sugars | 1.1 g |
| - Polyols | 0.8 g |
| - Starch | 12.0 g |
| Dietary Fiber | 0.2 g |
| Protein | 2.2 g |
| Salt | < 0.01 g |

Serving Size: 1 banana (35 g)

| Nutrient | Amount per serving (35 g) |
|---|---|
| Total Calories | 23 kcal |
| Total Fat | 0.2 g |
| - Saturated Fat | 0.1 g |
| - Trans Fat | 0 g |
| Total Carbohydrates | 4.9 g |
| - Sugars | 0.4 g |
| - Polyols | 0.3 g |
| - Starch | 4.2 g |
| Dietary Fiber | 0.1 g |
| Protein | 0.8 g |
| Salt | < 0.01 g |