Received: 13 September 2021 | Revised: 25 October 2021 | Accepted: 27 October 2021

DOI: 10.1111/joss.12722

ORIGINAL ARTICLE

Journal of Sensory Studies | WILEY

Sensory analysis of nougat: Methodology, training, and validation of a panel for protected geographical indication *Torró d'Agramunt*

Laura López-Mas[1,2] | Roser Romero del Castillo[1,2]

[1]Fundació Miquel Agustí, Campus del Baix Llobregat, Castelldefels, Spain

[2]Department d'Enginyeria Agroalimentària i Biotecnologia, Universitat Politècnica de Catalunya (UPC), Castelldefels, Spain

Correspondence
Roser Romero del Castillo, Department d'Enginyeria Agroalimentària i Biotecnologia, Universitat Politècnica de Catalunya (UPC), Carrer Esteve Terradas 8, Edifici D4, Castelldefels 08860, Spain.
Email: roser.romero.del.castillo@upc.edu

Present address
Laura López-Mas, Food Technology Program, Institute of Agrifood Research and Technology (IRTA), Monells, Spain

Funding information
Regulating Board of PGI Torró d'Agramunt

Abstract

Nougat-type confections, made with nuts, honey or sugar, and/or egg whites, are consumed in many countries. *Torró d'Agramunt* is a nougat produced in northeast Spain that has been awarded the European quality label Protected Geographical Indication (PGI). When sensory descriptors are included in the PGI's operating regulations, the sensory quality of products with the label must be guaranteed. The current study established eight descriptors and reference ranges for *Torró d'Agramunt*, differentiating between products labeled "supreme category" (containing ≥60% nuts) from those labeled "extra category" (containing ≥46% nuts), and developed a method to train a panel of tasters to evaluate this product. Applying the method also showed that sensory analysis is useful for identifying products that are nearing their expiry date. The work conducted within this study represents a step toward the standardization of the approach to the sensory analysis of nougats and similar products.

Practical Applications

Sensory analysis is a way to objectively characterize the attributes of products. Determining whether products fulfill established criteria for certain attributes is important for quality control and ensuring consumer trust. The present study aimed to devise a standardized method for the sensory analysis of nougats and similar products. The approach developed has enabled the sensory characterization of various PGI *Torró d'Agramunt* using the selected descriptors, making it possible to establish a sensory profile according to the percentage of nuts included in the product and to evaluate changes in the sensory profile that occur as the product approaches its expiry date. Training the panel and discussing the descriptors underlined the need for feedback between the Regulating Board, the director of the panel, and the tasters. This process resulted in a fast, feasible method that can be applied for quality control of other products or other quality labels.

1 | INTRODUCTION

The European Union's geographical quality labels Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) were created to promote rural development, preserve cultural heritage and countryside, and protect consumers by safeguarding high-quality agri-food products. The technical characteristics of products protected under these labels, including sensory characteristics, must be specified in the product's charter as laid down in Regulation EU 1151/2012 (OJEU, 2012). To date, no official methods or guidelines detailing how to control and guarantee the sensory characteristics of these products have been published, so currently different types of public and/or private entities in each country use different approaches for this purpose (Pérez-Elortondo et al., 2018). Recently, the European Sensory Science Society (E3S) has published a general guidelines for sensory analysis of PDO products (Pérez-Elortondo & Zannoni, 2021), in which some food products are given as example (i.e., olive oil, wine, cheese, and asparagus), although for nougat are not provided. Thus, it is necessary to establish standardized methods to accredit and control each of the products protected under a quality label.

Following the general recommendations for sensory analysis (ISO, 2019), controlling the sensory quality of products protected under PDO and PGI labels normally begins with selecting and clearly defining descriptors. It is important to include enough descriptors to define the product while keeping the number to a minimum to ensure feasibility. Moreover, the most appropriate references must be selected for each descriptor, as these references are essential for training members of tasting panels. The regulating board, the director of the panel, and the tasters must work together to define the descriptors and references. A wide variety of products enjoy PDO and PGI status; many of these products have never been subjected to sensory analysis, so the process needs to be adjusted as experience accumulates. The panel of tasters must be recruited, selected, and trained according to established norms, always ensuring that the panel receives sufficient training to achieve sufficiently accurate results.

European quality labels protect some kinds of nougat. These confectionaries are thought to have originated in Asia, and the earliest records of their elaboration come from the Middle East and Persia. Like many other foods, nougats were brought to Europe by the Arabs (Flandrin & Montanari, 2011), and today nougats are consumed throughout the world. All nougats are made with honey or sugar and nuts, but other ingredients and the process of elaboration can vary in different territories, giving rise to different products, for example, *Gaz* (known as Persian nougat in Europe and the United States), *Halva*, or *Sohan asali* (Hartel & Hartel, 2014). Nougats made with almonds or other nuts such as hazelnuts, peanuts, or walnuts are very popular in Spain, where they are called *turrón* (or *torró* in Catalan-speaking regions), and in Italy, where they are called *torrone* (Vázquez-Araújo, Chambers, & Carbonell-Barrachina, 2012). In addition to commercial brands, some of these nougats are protected under European quality labels; at present, four European nougats have been awarded PGI status: *Torrone di Bagnara*, *Turrón de Jijona*, *Turrón de Alicante*, and *Torró d'Agramunt*.

Some publications reported the sensory characteristics, physical and chemical properties, volatile composition, and/or instrumental analysis of the texture of different types of European nougats. Vázquez-Araújo, Verdú, Enguix, and Carbonell-Barrachina (2008) and Vázquez-Araújo, Verdú, and Carbonell-Barrachina (2008) used a trained taste panel to analyze and compare the volatile composition and sensory characteristics of different products from the PGIs *Turrón de Jijona* and *Turrón de Alicante* made with orange-blossom honey, rosemary-blossom honey, or sugar alone (control). Both the trained taste panel and ordinary consumers found more intense honey flavor than smell and classified the products in the following order: orange-blossom > rosemary-blossom > control; however, only the trained panel was able to correctly identify which products were elaborated with which type of honey. Narbona, García-García, Vázquez-Araújo, and Carbonell-Barrachina (2010) studied the flavor profile of *Turrón a la piedra*, a type elaborated without honey that is flavored with cinnamon and lemon zest. In particular, the study was focused on studying the flavor profile resulting from including propolis (Narbona et al., 2010) and royal jelly (García-García et al., 2012) in this type of nougat, with the aim of determining the threshold where the flavor of the product changed to determine the maximum amount of these two functional ingredients that can be added. They found that adding 50 mg propolis per 100 g of nougat did not affect the sensory profile; by contrast, adding 500 mg of royal jelly per 50 g of nougat modified the sensory profile slightly but improved the health benefits for consumers. In another study, Vázquez, Verdú, Miquel, Burlo, and Carbonell-Barrachina (2007) analyzed changes in the activity of water, total soluble solids, color, hydroxymethylfurfural, volatile compounds, and sensory characteristics during the concentration of sugars and honey and whitening with ovalbumin in three types of honey (orange-blossom, rosemary-blossom, and mixed-flower). They found a significant loss of flavor during the processing of the nougat, without differences among the types of honey.

Speziale, Vázquez-Araújo, Mincione, and Carbonell-Barrachina (2010a, 2010b) studied the volatile compound composition and sensory profile of *Gianduja torrone* and *Vainilla torrone*, the most widely consumed nougats in Reggio Calabria (Southwest Italy). Analyzing 15 attributes, they concluded that in *Gianduja torrone*, the main differential factor between products was the gianduja (chocolate-hazelnut coating), whereas the almond and honey flavors were similar in all the samples. By contrast, in *Vanilla torrone*, despite the addition of artificial flavorings, the quality of the roasted almonds and the honey also played an important role.

Vázquez-Araújo, Verdú, Murcia, Burlo, and Carbonell-Barrachina (2006) analyzed the texture of three categories of *Turrón de Jijona* ("extra," "supreme," and "improved supreme") with three instrumental tests (Magness–Taylor, compression, and texture profile analysis [TPA]) to determine the influence of small differences in the moisture and composition of the different sugars. They concluded that TPA provided the most useful information for controlling the hardness and oil residues during manufacturing. Hojjati, Speziale, Noguera-Artiaga, and Carbonell-Barrachina (2015) compared the instrumental texture, volatile composition, and sensory

profile of *Gaz*, one type of traditional Iranian nougat, between products made with almonds versus those made with pistachios. Their results showed that the type of nut included determines the intensity of key flavor attributes, but the only texture attribute they affect is hardness.

Although various studies have used sensory analysis to evaluate different types of nougats, few have focused exclusively on sensory characterization. Two sensory characterization studies reported by Vázquez-Araújo, Pérez-Castejón, Verdú, and Carbonell-Barrachina (2005); Vázquez-Araújo et al. (2012) focused on developing a sensory lexicon to use in different types of almond-based *turrón* as well as some references and methods for training a panel of tasters for the PGIs *Turrón de Alicante* and *Turrón de Jijona*. Verdú, Serrano-Megías, Vázquez-Araújo, Pérez-López, and Carbonell-Barrachina (2007) compared manufacturers' and consumers' concepts of high quality for PGI *Turrón de Jijona* by asking them to select the most important descriptors. Consumers chose high sweetness, high compactness, and low oiliness, whereas manufacturers chose pronounced honey flavor and pronounced almond flavor, because these are the most expensive ingredients. Nevertheless, these studies about the sensory characterization of nougats all referred to those under the protected labels PGI *Turrón de Jijona* and PGI *Turrón de Alicante*. No studies have used sensory analysis to characterize nougats from PGI *Torró d'Agramunt*.

The nougats protected under the PGI *Torró d'Agramunt* label (R [UE] 1241, 2002) are made in the town of Agramunt in the province of Lleida (Catalonia, Northeast Spain). The PGI regulations stipulate that these nougats must be made from honey (at least 10%), roasted and peeled hazelnuts (*Corylus avellana*, var. Negreta) or almonds (*Prunus dulcis*, var. Marcona), sugar and/or glucose syrup, egg whites or egg-white powder, and wafer (Figure 1). The nougats are commercialized in two categories: "supreme" (≥60% hazelnuts or almonds) and "extra" (≥46% hazelnuts or almonds). They are manufactured in two shapes (round disks or rectangular bars) and in different sizes (Figure 2). PGI *Torró d'Agramunt* nougats are differentiated from other Spanish nougats by their irregular, coarse appearance, and the thin layers of wafer on the bottom and top of the product (Bernaus, Bertran, & Cots, 2012); moreover, whereas other Spanish nougats such as those protected under PGI *Turrón de Alicante* or PGI *Turrón de Jijona* are traditionally made only with almonds, those under PGI *Torró d'Agramunt* can also be made with hazelnuts.

In Catalonia, the regional government's Department of Agriculture is promoting the control of the sensory quality of products protected under PDO and PGI labels. Together with the Regulating Board of PGI *Torró d'Agramunt*, the government contracted our team to develop and implement a standardized methodology to certify the sensory quality of nougats commercialized under the PGI. With the aim of sharing this technological development with other regulating boards that work with similar products, we proposed to: (a) Define the list of descriptors and references for training a taste panel in accordance with the specifications laid out in the PGI *Torró d'Agramunt* charter, (b) Train and validate the official panel that will assess the

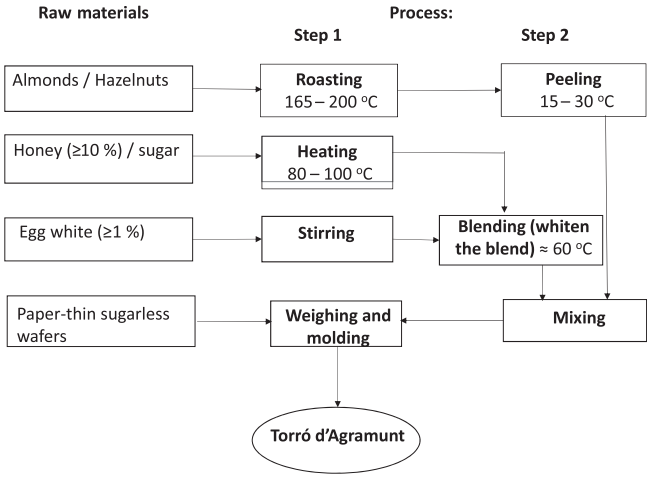


FIGURE 1 Process for elaborating nougats protected under the PGI *Torró d'Agramunt* quality label

FIGURE 2 Shape of nougats protected under the PGI *Torró d'Agramunt* quality label: rectangular bar (left) and round disk (right)

sensory quality of nougats marketed under the quality label, (c) Apply the methodology developed to describe the sensory profile of diverse samples from the commercial brands that use the PGI *Torró d'Agramunt* label, and (d) Check that each descriptor established and its theoretical limits correspond to the reality of the product.

2 | MATERIALS AND METHODS

2.1 | Panelists

Using convenience sampling, 19 candidates were recruited through advertisements on signs and social media. Of these, 11 panelists (5 men and 6 women; ranged between 25 and 60 years old) passed the selection tests and completed the specific training for the sensory analysis of *torró* established by ISO regulations 8586 (ISO, 2012) and 3972 (ISO, 2013). All sensory analyses were done in a tasting room that surpassed the requirements specified in ISO regulation 8589 (ISO, 2007).

2.2 | Descriptors, references, and training

The description of the sensory characteristics in the PGI *Torró d'Agramunt*'s specifications state that the product must be: (i) light brown or golden-colored, (ii) made of a hard paste with tiny air pockets that make it easy to break, giving it a coarse irregular texture, (iii) crunchy but melt in the mouth, (iv) intensely sweet, and (v) shaped into round disks between thin layers of wafer or into rectangular bars (MAPA, 2002). Following ISO 5492 (ISO, 2010), our team worked together with the panel and the Regulating Board, using the literature (Vázquez-Araújo et al., 2005, 2012), to elaborate a preliminary list of the descriptors that best characterized the attributes of the nougats specified in the PGI regulations. But also, to define their preliminary intensity and the most appropriate references for the intensity of each descriptor.

For this purpose, a continuous 10-point semistructured scale (with 0 representing the minimum intensity and 10 the maximum intensity), anchored in the center (Lawless & Heymann, 2010), was used for each descriptor, with the exceptions of color (measured on a 6-point scale, where 1 was the lightest color and 6 the darkest), and the defects bitterness and rancidity (classified into three categories: absent, slightly present, or present).

Afterward, the panel underwent a total of 20 hr of training in 12 sessions. The first sessions focused on familiarizing panelists with the theory of sensory analysis and with the product, the descriptors, and the references. The remaining sessions were devoted to training the panel for the descriptors chosen, first concentrating on one or two attributes (i.e., sweetness and fusibility; crunchiness and hardness; honey flavor, rancidity, and bitterness) and then on all the attributes together. The training sessions also served to establish the definitive approach to the evaluation of each descriptor (e.g., to assess fusibility, keep the product in the mouth for 20 s). The last training sessions consisted of tasting different samples of *torró* to establish the repeatability and reproducibility of the panelists before the validation of the panel to verify their discriminant capacity. To check the repeatability of the tasters, four samples of *torró* were tasted in the same session, being two of them the same sample (supreme category). The reproducibility was verified tasting two samples (extra and supreme categories) in two different days.

2.3 | Sample preparation and presentation

Samples were stored at constant temperature (18–20°C), in dry place away from direct light. The samples were taken from newly opened packages; each package of round shaped nougat contained 300 g, whereas bar shaped contained 500 g. Samples preparation consisted in placing homogeneous portions of nougat on stainless steel bowls with a random three-digit code. Bar shaped portions weighed about 7–8 g each one and measure around 3–4.5 × 1.5 cm (depending on the height of the nougat), two portions were served to each panelist. Round shaped nougat was cut in four, each portion weighed about 7–8 g, two portions were served to each panelist. Participants were presented with the samples simultaneously (Vázquez-Araújo et al., 2012) in the booth, along with a glass of water, apple slices for cleansing the mouth between samples, and the tasting form to be completed (Appendix A).

2.4 | Validation of the panel

2.4.1 | Samples

Once the panel was trained, its discriminant capacity was tested. We used samples from three manufacturers (A, B, and C); samples from two of these manufacturers also differed in the expiry date (Table 1).

2.4.2 | Procedure

Each of the three samples was analyzed in duplicate in two separate sessions.

TABLE 1 Characteristics of the three samples of nougats marketed under the PGI *Torró d'Agramunt* quality label used to validate the trained panel (September 2019)

Characteristics	Brand A	Brand B	Brand C
Category/B or R	Supreme/B	Extra/R	Extra/R
Nut	Almond	Hazelnut	Hazelnut
Expiry date package 1	Apr-21	Oct-19	Nov-19
Expiry date package 2	Apr-21	Oct-20	Oct-20

Abbreviations: B, bar; R, round.

2.5 | Application of the methodology developed for elaborating the sensory profile of various samples from different brands included in the PGI *Torró d'Agramunt*

2.5.1 | Samples

A total of 10 samples were evaluated: two produced for each of the five brands included in the PGI for the 2019 Christmas campaign (the main consumption of this nougat is around Christmas; Table 2).

2.5.2 | Procedure

Five tasting sessions were carried out using the exact same procedure as in the "sample preparation and presentation" section. All samples were analyzed in duplicate in two different sessions in which each panelist analyzed four samples presented simultaneously.

2.6 | Re-evaluation of the descriptors and theoretical limits of each descriptor to adjust them to the products' actual commercial conditions

Based on all the experimental data collected during the training of the panel and a thorough discussion of the descriptors and their application to the commercial lots, we reconsidered the ranges of the values of the descriptors to be considered acceptable for the quality label PGI for each quality category ("extra" or "supreme").

2.7 | Statistical analysis of the results

To analyze the repeatability and reproducibility of the panel, the mean and standard deviation (*SD*) of the samples were calculated according to ISO 8586 standards (ISO, 2012). The reference values for acceptable *SD* were the ones proposed by Pérez-Elortondo et al. (2007).

To compare samples, an analysis of variance (ANOVA) was carried out, using in the linear model $x_{ijk} = \mu + \upsilon_i + c_j + p_{ij} + e_{ijk}$ to calculate the sample effect (υ), taster effect (c), and the interaction sample*taster (p) from the fixed factors (sample and taster) together with Tukey's Honest Significant Difference (HSD) post hoc test.

To analyze the descriptors bitterness and rancidity (0 = absent, 1 = slightly present, 2 = present), an ANOVA was performed considering an interval scale where 0 is 1, 1 is 2, and 2 is 3 (Lea, Næs, & Rodbotten, 1998). To determine the effect of the expiry date on the sensory profile of the nougats, ANOVA and Tukey's HSD test were used, considering the panelists as repetitions of each sample. In these analyses, only data from the validation of commercial brands B and C were included, because these samples from these two brands included products with different expiry dates. To study patterns among samples in terms of quantitative descriptors, a principal components analysis (PCA) was used.

The R statistical program (R-project, 2020) was used for ANOVA and Tukey's HSD test, considering factors with $p \leq .05$ significant. XLSTAT statistical program (Addinsoft, 2020) was used for conducting the PCA.

TABLE 2 Characteristics of the samples of nougats marketed under the PGI *Torró d'Agramunt* quality label from the 2019 Christmas campaign

Code	Shape	Category	Nut	Expiry date
E1Eav	Round	Extra	Hazelnut	02/2021
D1Eav	Round	Extra	Hazelnut	04/2021
B1Sam	Bar	Supreme	Almond	02/2021
E2Sam	Bar	Supreme	Almond	04/2021
A1Sam	Bar	Supreme	Almond	10/2020
A2Eav	Round	Extra	Hazelnut	10/2020
D2Sam	Round	Supreme	Almond	04/2021
C1Eam	Round	Extra	Almond	03/2021
B2Eav	Round	Extra	Hazelnut	03/2021
C2EavB[a]	Round	Extra	Hazelnut	05/2020

[a]Organic sample.

3 | RESULTS AND DISCUSSION

3.1 | Reaching a consensus about descriptors and their intensities: training the panel

Working together with the panelists and the Regulating Board based on the specifications in the PGI *Torró d'Agramunt* charter, and using as a basis the lexicon for *Turrón* developed by Vázquez-Araújo et al. (2005, 2012), we elaborated a preliminary list of eight descriptors and their corresponding scales to characterize the nougats protected under this quality label (Table 3).

The sensory lexicon for nougat published by Vázquez-Araújo et al. (2012) included 41 attributes and it was obtained after evaluating 49 samples of different brands and commercial categories of nougat. In another work published in Spanish (Vázquez-Araújo et al., 2005), the tasting score sheet for *Turrón de Alicante* used included 18 attributes, although some of those were not strictly sensory attributes per se (i.e., type of almonds or honey quantity). In the case of the present study, a single category of nougat was evaluated, similar to *Turrón de Alicante*, hence, only eight attributes were selected from those proposed by Vázquez-Araújo et al. (2005, 2012). Excessively long lists of descriptors make panelists' work wearisome and reduce the number of samples that can be assessed in each tasting session as fatigue may appear. The list of descriptors selected was short enough to avoid straining panelists, but long enough to ensure that the products fulfill the requirements specified in PGI *Torró d'Agramunt*'s charter.

According to a study financed by the European Commission and conducted by London Economics (2008), the main reasons adduced

TABLE 3 Descriptors, intensity scale (Regulating Board of PGI *Torró d'Agramunt*, 2018), and references for training panelists in the sensory analysis of products protected under the quality label

Descriptor	Definition	Intensity scale[a]	References and intensities
Color	Sensory perception of saturation and clarity induced by the stimulation of the retina by light waves of various lengths[b]	2–5 (Scale from 1 to 6)	*Appearance*: Two scales were elaborated; for round and bar shaped nougats. Four pictures were used for each scale. To represent the variability in the color of PGI commercial nougats, pictures were taken of samples recently after manufacture, in the middle and at the end of its expiry date, ranging from 2 (light cream color) to 5 (caramel color typical of coffee with milk).
Sweetness	Basic taste produced by aqueous solutions of natural or synthetic substances such as sucrose or aspartame[b]	8–9	*Taste*: *Reference for first training session*$_1$: 4% sucrose solution = 4 6% sucrose solution = 6 8% sucrose solution = 8 Preparation: 20 ml of each solution for each taster. *Reference for further training sessions*$_2$: Yogurt cake = 4 Yogurt cake with double sugar = 6 Preparation: 25 g of each cake for each taster. Ingredients: 3 eggs, 1 yogurt (x[c]), 3x flour, 8 g baking powder, 1/2x sunflower seed oil, 1 or 2x sugar.
Honey flavor	Perception of honey with all the aromatic components that it can give off	>3	*Flavor*:[d] *Reference*: 4% honey solution = 4.5 6% honey solution = 7.5 Preparation: 20 ml of solution of mixed-flower honey (d = 1.43 g/ml) for each taster. Red booth light.
Crunchiness	This descriptor refers to the fragility of the substance and its cohesion and hardness and the force necessary to break it into smaller pieces; references include raw apple or carrot, crispy potato crisps/chips[b]	5–8	*Texture*: *Reference*$_1$: gummy bear = 0–1 Preparation: one per taster. *Reference*$_2$: cracker = 6–7 Preparation: one per taster. *Reference*$_3$: raw carrot = 7–9 Preparation: 3 cm per taster.
Hardness	Force required to achieve a determinate deformation, penetration, or breakage of a product[b]	5–8	*Texture*: *Reference*$_1$: breadsticks = 4–5 Preparation: one per taster. *Reference*$_2$: honey hard candy = 10 Preparation: one per taster.
Fusibility	Very low level of force required to chew a solid product until it is ready to swallow[b]	4–7	*Texture*: *Reference*$_1$: raw almond = 0 Preparation: one per taster. *Reference*$_2$: honey hard candy = 5 Preparation: one per taster. *Reference*$_3$: lindt chocolate (52% cocoa) = 9–10 Preparation: 5 g per taster.
Bitterness	Basic taste of substances such as quinine and caffeine diluted in aqueous solutions[b]	0 (<1)[e] (0–2)	*Taste*: *Reference*: 33% solution of Schweppes tonic water = 7–8 Preparation: 20 ml per taster.
Rancidity	Unpleasant smell and taste due to chemical alteration due to decomposition of oils	0 (<1)[e] (0–2)	*Flavor*: *Reference*$_1$: Rancid almond/hazelnut = 7–8 *Preparation*: peeled raw almonds/hazelnuts and forcing its rancidity (with time, temperature, or both). *Reference*$_2$: nougats approaching its expiry date. *Preparation*$_2$: bar shaped (3–4.5 × 1.5 cm), round shaped (1/4 disk).

[a]All the descriptors are measured on a scale ranging from 0 to 10, except color (scale from 1 to 6), and bitterness and rancidity (scale from 0 to 2).
[b]Definitions from ISO 5492 (ISO, 2010).
[c]x is the size of a commercial yogurt container for individual consumption (125 ml).
[d]Flavor: taste + retronasal olfaction + trigeminal sensations.
[e]The value <1 was proposed because one or more tasters might detect a very slight presence of the descriptor and this result would not be important for the totality.

by PGI and PDO producers for using those quality labels are of economic nature, allowing them gaining or securing market share to maintain the viability or profitability of their products. Therefore, although adding extra descriptors may be interesting from an academia point of view, it would increase the time panelists require to assess each sample and, consequently, the cost of the whole evaluation.

An exception was made for honey flavor, as this descriptor was studied although it was not specifically gathered in the *Torró d'Agramunt* charter. The main reason is that, as already reported by Verdú et al. (2007), honey flavor is one of the most important descriptors for *Turrón de Jijona* manufacturers, in the same vein, *Torró d'Agramunt* Regulatory Board also considered its importance.

To assess the intensity of the descriptors, panelists need good references. Substances used as references should be stable and reproducible over time (Drake & Civille, 2002; Lawless Jr & Civille, 2013). Most of the literature available use commercial food products as descriptors' references (Chambers, Lee, Chun, & Miller, 2012; Chun, Chambers, & Han, 2020; Jaffe, Wang, & Chambers, 2017; Vázquez-Araújo et al., 2012), sometimes those products are country-dependent, which difficult other researchers to reproduce it. Therefore, in order to increase the reproducibility of the sensory evaluation methods, in the current study, references were common products that were easily obtainable (e.g., handmade cake) and as similar as possible to the products being assessed.

3.2 | Repeatability and reproducibility of the panelists

The results of the best (Panelist 1) and the worst taster (Panelist 2), taken as a reference a *SD* ≤0.5 (Pérez-Elortondo et al., 2007), showed that the repeatability of the trained tasters varied between 62.5% and 100% (Table 4).

The percentage of the reproducibility, taken as a reference *SD* ≤0.5 and *SD* ≤1.0, was calculated (Table 5). As an example, the values of two panelists showed that the individual reproducibility was 75% when a *SD* ≤0.5 was taken as a reference and between 87.5% and 100% when it was *SD* ≤1. The most difficult descriptor to evaluate was honey flavor, followed by hardness, maybe because the samples came from different packages.

TABLE 4 Mean, standard deviation, and repeatability (*SD* ≤.5) of PGI *torró* sample of supreme category tasted twice in the same session of the best (Panelist 1) and the worst (Panelist 2)

	Color	Sweetness	Honey flavor	Crunchiness	Hardness	Fusibility	Bitterness	Rancidity
Panelist 1								
Mean ($N = 2$)	3.0	8.7	4.6	8.9	8.1	5.0	0.0	0.0
SD sample	0.0	0.4	0.0	0.0	0.5	0.0	0.0	0.0
Repeatability 100%								
Panelist 2								
Mean ($N = 2$)	3.5	6.1	4.8	8.5	7.6	4.6	0.0	0.0
SD sample	0.7	0.9	0.4	0.6	0.3	0.3	0.0	0.0
Repeatability 62.5%								

Note: *SD*: standard deviation.

TABLE 5 Mean, standard deviation, and reproducibility (*SD* <.5 or <1.0) of a supreme (Su) and extra (E) category PGI *torró* tasted in two different sessions of two panelists (Panelist 1 and Panelist 3)

	Color		Sweetness		Honey flavor		Crunchiness		Hardness		Fusibility		Bitterness		Rancidity	
Quality	**E**	**Su**	**E**	**Su**	**E**	**Su**	**E**	**Su**	**E**	**Su**	**E**	**Su**	**E**	**Su**	**E**	**Su**
Panelist 1																
Mean 2 sessions	2.0	3.0	9.2	8.2	6.3	4.9	8.4	8.4	6.5	7.2	6.0	4.3	0.0	0.5	0.0	0.5
SD sample	0.0	0.0	0.1	0.4	0.9	1.6	0.8	0.0	0.5	1.5	0.0	0.1	0.0	0.7	0.0	0.7
Mean *SD*	0.0		0.3		1.2		0.4		1.0		0.		0.4		0.4	
Reproducibility (*SD* <.5) 75%, (*SD* <1.0) 87.5%																
Panelist 3																
Mean 2 sessions	2.5	3.0	8.9	8.0	5.4	4.4	7.7	78	7.8	8.4	7.4	5.5	0.0	0.0	0.0	0.0
SD sample	0.7	0.0	0.0	0.3	1.3	0.2	0.3	0.0	0.6	0.8	0.5	0.4	0.0	0.0	0.0	0.0
Mean *SD*	0.4		0.1		0.8		0.1		0.7		0.4		0.0		0.0	
Reproducibility (*SD* <.5) 75%, (*SD* <1.0) 100%																

Abbreviations: E, extra category; Su, supreme category.

3.3 | Validation of the panel

In the validation study (11-member panel), significant differences among samples were observed for all descriptors except bitterness (results not shown). Significant differences among tasters were observed for the attributes color, sweetness, honey flavor, and fusibility. The significance of the taster factor in the ANOVA does not lower the panel's ability to discriminate among samples provided that the difference in the panelists' assessments results from differences in the application of the scale (O'Mahony, 1985). Finally, the sample * taster interactions were significant for sweetness, honey flavor, and fusibility (results not shown). The problem is that differences in the use of the scale sometimes manifest in peculiar interactions between the taster and the sample that are reflected in the sample * taster interaction.

The ANOVA data can be used to optimize the discriminant capacity of the panel (ISO, 2012). The best way to do this is to use the original data from the validation study to identify panelists with nonlinear deviations in their assessments (O'Mahony, 1985) when some descriptors show interaction sample * taster and to retrain them to internalize the scales until the taster effect disappears. An alternative approach that can be used when the panel is large enough (>10 panelists) is to identify the panelists responsible for the interaction and eliminate their assessments from the calculation, provided that data from at least eight panelists can be used (Lawless & Heymann, 2010). The interactions in the ANOVA showed that our panel's discriminant capacity could be improved, so the three panelists who were mainly responsible for the taster effect and sample * taster interaction were retrained individually to improve their internalization of the scales. Nevertheless, since these panelists failed to achieve the level of internalization of the scales required, these panelists were excluded from the functional panel. Thus, the analyses were done on data from eight tasters. The results of these analyses continued to show differences among tasters' assessments of sweetness, honey flavor, and fusibility, but the sample * taster interactions had disappeared (Table 6).

The descriptors for which the panelists had the greatest deviations in the internalization of the scales were sweetness, honey flavor, and fusibility (lowest values in the significance of the taster effect). Vázquez-Araújo et al. (2012) also found that honey flavor can be masked by other ingredients such as nuts, toasted sugars, and the toasted honey itself, making it difficult to assess this attribute. Despite the difficulties evaluating this attribute, in the work carried out by Vázquez-Araújo et al. (2005), the panelists were able to distinguish samples of *Turrón de Alicante* made with rosemary-blossom honey from those made with orange-blossom honey.

Comparing the mean values for each descriptor between the three brands used for the validation showed that some nougats do not fulfill the theoretical requirements for sweetness reached in consensus with the Regulating Board (Table 7). The validation study also revealed differences between nougats in the "extra" and "supreme" categories in various descriptors. The values for sweetness, honey flavor, and fusibility were higher for nougats in the "extra" category. These results make sense because nougats in the "extra" category contain a higher proportion of honey and sugar, whereas those in the "supreme" category have a higher proportion of nuts. Although the characteristic honey volatile compounds decreased during heating step (80–100°C; Vázquez et al., 2007), differences in intensity of the honey flavor may also be explained as some commercial *turró* samples differed in the type of honey and/or the initial proportion of honey, but always surpassing the 10% specified in the charter.

The time elapsed from the date of manufacture affects the products' crunchiness, hardness, and rancidity (Table 8). Nevertheless, although the values for these descriptors were worse in samples that were nearing their expiry date, the values for crunchiness and

TABLE 6 Significance of the ANOVA for the evaluation of all the descriptors in three samples of *torró* in the validation study, taking into consideration the main factors and their interactions after excluding the panelists responsible for the interactions (analysis includes data from the remaining eight panelists)

Factor	Color	Sweetness	Honey flavor	Crunchiness	Hardness	Fusibility	Bitterness	Rancidity
Sample (S)	0.0389	0.0043	0.0034	0.0427	0.0284	0.0117	0.2740	0.0241
Taster (T)	0.0749	0.0017	0.0004	0.7023	0.8110	<0.0001	0.8060	0.6649
Repetition	0.6632	0.1692	0.7634	0.8519	0.8785	0.0027	0.1100	1.0000
S*T	0.6262	0.1017	0.1271	0.9924	0.9999	0.7505	0.6790	0.9917

Note: The number in each cell represents the significance on Fisher's exact test.

TABLE 7 Comparison of the mean values for the descriptors found for the three brands used in the validation of the panel

Sample	Color	Sweetness	Honey flavor	Crunchiness	Hardness	Fusibility	Bitterness	Rancidity
A/Bar/Supreme/Almond	2.3 a	7.3 b	5.4 b	8.3	8.0 a	5.4 b	0.1	0.0 b
B/Round/Extra/Hazelnut	2.0 b	8.3 a	6.7 a	7.0	6.4 b	6.0 a	0.2	0.5 ab
C/Round/Extra/Hazelnut	2.1 ab	8.2 b	6.4 a	6.8	6.5 b	6.1 a	0.3	0.6 a
PGI reference values/2018	2–5	8–9	>3	5–8	5–8	4–7	≤0.5	≤0.5

Note: Letters a,b: different letters in the same column indicate statistically significant differences ($p \leq .05$); the absence of letters within a column indicates no statistical differences. All descriptors were measured on a scale ranging from 0 to 10, except color (1–6), bitterness, and rancidity (0–2).

hardness were still within the reference range specified in the Regulating Board's charter (5–8). The values for rancidity in samples approaching their expiry dates, however, doubled the maximum permitted in the regulations. It is important to point out that the Regulating Board supplied these samples and that they had been properly stored and were analyzed within a few days of their delivery. These results underline the importance of quality control for sensory traits in stipulating the shelf life of these products, because the human sense of smell can detect molecules resulting from the peroxidation of lipids at very low concentration (Belitz & Grosch, 1992; Neugebauer, Granvogl, & Schieberle, 2020). Vázquez-Araújo et al. (2012) already pointed out that long storage periods may decrease sensory quality of *Turrón* even if they are within their shelf life. Martínez-Navarrete, Fito, and Chiralt (1996), demonstrated that textural properties of *Turrón de Jijona* measured with instrumental methods evolved during storage, being oil release from its matrix one of the main reasons. Even so, the textural properties of *Turrón de Jijona* greatly differ from those of the *Torró d'Agramunt*. However, no studies were found measuring the evolution of the textural properties of nougats more similar to *Torró d'Agramunt*, such as *Turrón de Alicante*. The closest article found dealing with a nougat similar in texture with *torró* was the one of Vázquez-Araújo et al. (2005), which provided a tasting sheet in which stickiness was considered as a defect, although no results were shown regarding panelists' scores. As experience accumulates with the *torró* samples evaluated, it was empirically found that loss of hardness and crunchiness evolved into stickiness. Therefore, it may be considered that stickiness defect can be inferred from loss of hardness and crunchiness, both descriptors included in the sensory description method proposed.

3.4 | Application of the methodology developed to determine the sensory profile of the brands sold under the PGI *Torró d'Agramunt*: Christmas campaign 2019

The results of the sensory analyses of the nougats sold in the 2019 campaign confirm the findings of the validation study, showing a clear differentiation between the sensory profiles of the "extra" and "supreme" categories (Table 9). Values of the descriptor crunchiness were lowest for the two samples from the "extra" category (C1Eam:

TABLE 8 Effect of the expiry date on the sensory profile of two samples from two different commercial brands of the PGI *Torró d'Agramunt* ("extra" category) that were used during the validation of the panel and that only differed on their expiry date

Sample	Expiry date	Color	Sweetness	Honey flavor	Crunchiness	Hardness	Fusibility	Bitterness	Rancidity
B	October 2019	2.0	7.7	6.6	5.6 b	5.5 b	5.9	0.0	1.1 a
B	October 2020	2.0	8.8	6.9	8.1 a	7.3 a	6.1	0.3	0.2 b
C	November 2019	2.0	8.2	6.3	5.8 b	5.2 b	6.6	0.4	1.0 a
C	October 2020	2.2	8.1	6.4	8.1 a	7.8 a	5.6	0.2	0.2 b
PGI reference values/2018		2–5	8–9	>3	5–8	5–8	4–7	≤0.5	≤0.5

Note: Letters a,b: different letters in the same column indicate statistically significant differences ($p \leq .05$); the absence of letters within a column indicates no statistical differences. All descriptors were measured on a scale ranging from 0 to 10, except color (scale ranging from 1 to 6), and bitterness and rancidity (scale ranging from 0 to 2). The columns in bold indicate the attributes that change according to the expiration date.

TABLE 9 Mean values for the descriptors used to elaborate the sensory profile of PGI *Torró d'Agramunt* from samples of products from the Christmas campaign in 2019

Sample	Category	Color	Sweetness	Honey flavor	Crunchiness	Hardness	Fusibility	Bitterness	Rancidity
C1Eam	Extra	2.8 a	7.4 bc	6.5 abc	7.4 bc	7.5 ab	5.2 ab	0.4	0.0 b
E1Eav	Extra	2.7 a	8.3 ab	6.8 ab	8.0 ab	6.8 b	5.8 a	0.3	0.2 ab
D1Eav	Extra	2.1 b	8.4 a	7.0 a	8.5 a	6.9 b	5.7 a	0.1	0.1 ab
A2Eav	Extra	2.1 b	8.2 ab	6.7 ab	8.0 ab	7.0 ab	5.2 ab	0.0	0.1 b
B2Eav	Extra	2.2 b	8.4 a	6.8 ab	8.0 ab	7.2 ab	5.2 ab	0.2	0.4 a
C2EavB	Extra	2.2 b	8.6 a	6.9 ab	5.0 d	5.4 b	5.8 a	0.1	0.1 b
E2Sam	Supreme	2.0 b	7.2 c	4.9 d	7.5 bc	7.5 ab	4.8 bc	0.1	0.0 b
B1Sam	Supreme	2.0 b	6.9 c	4.6 d	7.1 c	7.7 ab	4.5 bc	0.1	0.2 ab
D2Sam	Supreme	2.0 b	7.4 bc	5.7 bcd	7.5 bc	7.7 ab	4.8 bc	0.0	0.0 b
A1Sam	Supreme	2.6 a	7.2 c	5.6 cd	7.7 abc	7.8 a	4.3 c	0.3	0.1 b
PGI reference values/2018		2–5	8–9	>3	5–8	5–8	4–7	≤0.5	≤0.5

Note: Letters a–d: different letters in the same column indicate statistically significant differences ($p \leq .05$) in the Tukey test; the absence of letters within a column indicates no statistical differences. All descriptors were measured on a scale ranging from 0 to 10, except color (scale ranging from 1 to 6), and bitterness and rancidity (scale ranging from 0 to 2).

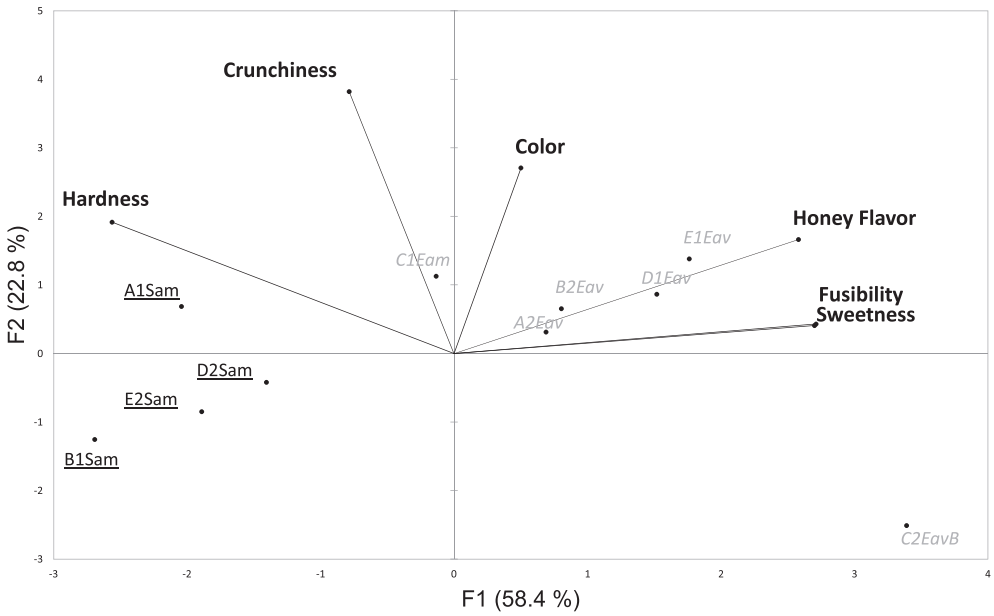


FIGURE 3 Principal components analysis graph showing the position of various samples in the plane determined by the first two factors. The angle of the vector with the axes indicates the correlation between the principal component and the original variable; the length of the vector is proportional to the variability in the original variable explained by each principal component. The percentages between parentheses refer to the variation explained by each principal component. Underlined names in black print correspond to nougats classified as "supreme" (containing ≥60% nuts); italicized names in light gray print correspond to nougats classified as "extra" (containing ≥46% nuts)

7.4 and C2avB: 5.0); both these samples were manufactured by the same company. Moreover, the sample with the lowest value for crunchiness was the one that was nearest its expiry date (5 months, compared to 10 months in the others), thus confirming the effect of time from manufacturing on crunchiness that was found in the validation study.

In the PCA, the first two factors explained 81.2% of the variance (Figure 3), whereas if the third factor is included, 96.4% of the variance is explained. The descriptors that correlated most strongly with the first factor were sweetness, honey flavor, hardness, and fusibility all with positive $r \geq .90$. The descriptor that correlated most strongly with the second factor was crunchiness, with $r = .83$. The samples analyzed form two clusters, corresponding to the "supreme" and "extra" categories. The two samples of nougats in the "extra" category that lie outside the cluster corresponding to this category (C1Eam and C2EavB) are both from the same company. C1Eam is classified as "extra," but it lies closer to the cluster of "supreme" category nougats. These findings are likely due to the fact that C1Eam is made with almonds rather than hazelnuts, as were all the samples of "supreme" category nougats. The other outlier, C2EavB, differed from the other nougats in two important aspects: it was organic (with different ingredients or ingredients from other suppliers), and it was 5 months closer to its expiry date. In an article published by Vázquez-Araújo et al. (2012), they compared two panels that evaluated four types of *Turrón* (Alicante, Jijona, Guirlache, and "a la Piedra") using 41 attributes (25 for flavor and 16 for texture). Their PCA results with all attributes and only with textural ones showed that they were not able to discriminate *Turrón de Alicante* samples from *Turrón de Girlache*, nor *Turrón de Jijona* from *Turrón a la Piedra*. When flavor attributes were considered, they were able to identify three groups *Turrón de Girlache*, *Turrón a la Piedra*, and a group formed by *Turrón de Alicante* and *Turrón de Jijona together*. In the present study, it was possible to distinguish extra and supreme categories with the descriptors chosen, as well as when samples approach its expiry date. This fact proves that eight descriptors is a suitable number for nougats similar to *Turrón de Alicante* or *Torró d'Agramunt* type.

3.5 | Adapting the descriptors and their reference ranges to conform with the commercial reality of the product

As a consequence of the panel's findings indicating distinct sensory profiles for products in the "supreme" and "extra" categories, the Regulating Board decided to modify the reference values and to define them separately for each category (Table 10). One of these changes consisted of lowering the lower limit of the descriptor sweetness for both categories (to ensure all samples compliance). On the other hand, the upper limit of the descriptor crunchiness was raised, because examining a larger number of samples revealed higher values of this descriptor (8.5; Table 9) and higher values of this descriptor cannot be considered a defect, because the PGI charter specifies that these nougats must be crunchy. Reference values for fusibility descriptor also were updated, the upper limit for "supreme" quality was lowered whereas the lower limit for "extra" quality was raised. This decision was based on the fact that nougats in the "extra"

TABLE 10 Descriptors agreed upon by the Regulating Board of PGI *Torró d'Agramunt* in 2020 resulting from the current study and changes with respect to those theoretically defined in 2018

Descriptor[a]	Supreme category		Extra category	
	2020	2018	2020	2018
Color	2–5	2–5	2–5	2–5
Sweetness	7–9	8–9	7–9	8–9
Honey flavor	>3	>3	>3	>3
Crunchiness	5–9	5–8	5–9	5–8
Hardness	5–8	5–8	5–8	5–8
Fusibility	4–6	4–7	5–7	4–7
Bitterness	≤0.5	≤0.5	≤0.5	≤0.5
Rancidity	≤0.5	≤0.5	≤0.5	≤0.5

[a]All descriptors were measured on a scale ranging from 0 to 10, except color (scale ranging from 1 to 6), and bitterness and rancidity (scale ranging from 0 to 2).

category contain a higher proportion of honey and sugar, ingredients with higher fusibility when compared with the "supreme" category, which contain a higher proportion of nuts. Therefore, it can be said that sensory quality standards may be dynamic, as panel training, the expertise with the product, and start working with new products, may change the previous references. According to Pérez-Elortondo et al. (2007), changes in consumer preferences, production systems, and/or new knowledge on sensory analysis research may cause changes in sensory quality standards.

Finally, the former references for the descriptor color were edible samples of nougat, however, those were changed, not the reference values but the references per se, because it was noted that its color changed over time. Following some of the guidelines established by Pérez-Elortondo et al. (2007) for color evaluation of PDO Idiazabal cheese, edible samples were replaced with photographs of nougat samples with the PGI quality label taken recently after manufacture and when the product was nearing its expiry date. To this end, four photographs of each shape (round disk and rectangular bar) were chosen to represent the variability in the color of commercial nougats to create a reference scale ranging from 2 (light cream color) to 5 (caramel color typical of coffee with milk).

The new reference ranges approved by the Regulating Board in 2020 were used to evaluate samples in the 2020 campaign.

4 | CONCLUSIONS

In this study, the combined efforts of the Regulating Board, the director of the panel, and the tasters enabled the definition of the six attributes that best describe the sensory profile of the nougats protected under the PGI *Torró d'Agramunt* label as well as of the two most important defects to be avoided (bitterness and rancidity). The study also was useful to define the reference ranges for these eight descriptors and the methodology for training a panel of tasters capable of describing the sensory characteristics and controlling the quality of this product. These results were used to train the panel and to analyze the sensory characteristics of samples of nougats marketed under the PGI, which led to the modification of the specifications to reflect the different sensory profiles of nougats in the "supreme" category (60% nuts) and those in the "extra" category (46% nuts).

The trained sensory panel's evaluation of nougats also proved useful for establishing their expiry date, for which the descriptors crunchiness, hardness, and rancidity were especially relevant.

Descriptive sensory analysis by a trained panel is essential for establishing the reference ranges for products' sensory profiles because the descriptors and their intensities (when specified) are often not based on repeated studies of the product and its variability. Establishing a method of quality control for sensory attributes of products protected under PDO and PGI quality labels must be a joint effort, with feedback from all the agents involved (the Regulating Board, the director the panel, and the tasters), and this process must be adapted to the products' actual circumstances.

Since nougat and similar products are appreciated in many countries, our work can benefit others who seek to establish a standard method for the sensory analysis of these confections. Standard methods of sensory analysis can strengthen quality labels by ensuring the inclusion of products that deserve them and excluding those that do not.

Few studies provide detailed guidelines on how the training of their panel is conducted and which results are obtained. In fact, most of them just mention that their panel has been previously trained. Therefore, we firmly believe that publishing data of the training conducted, increases the transparency of the work carried out while provides a basis for other researchers when starting new sensory analysis panels. In the same line, giving details on the references used, as well as the tasting sheet employed, may facilitate the reproducibility of the work, saving time and efforts to future researchers in the same or similar fields.

ACKNOWLEDGMENT

The authors thank the members of the tasting panel, the Regulating Board of PGI *Torró d'Agramunt*, and the Government of Catalonia.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

Laura López-Mas: Data curation, Investigation, Validation, Formal analysis, Methodology, and Writing—review. Roser Romero del Castillo: Conceptualization, Data curation, Investigation, Validation, Methodology, Writing—original draft, and Writing—review & editing.

ETHICS STATEMENT

Ethical approval

The study was conducted according to the guidelines of the Declaration of Helsinki.

Informed consent

At the beginning of the selection, participants were asked to provide consent to participate before proceeding.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.

ORCID

Laura López-Mas https://orcid.org/0000-0002-4567-5293
Roser Romero del Castillo https://orcid.org/0000-0002-4894-118X

REFERENCES

Belitz, H. D., & Grosch, W. (1992). *Lehrbuch der Lebensmittelchemie* (4th ed.). Berlin: Springer-Verlag GmbH & Co., KG.

Bernaus, R., Bertran, J. & Cots J. (2012). *Agramunt*: *Torronaires i Xocolaters*. Guissona, Lleida. Ed. Revista Sió. (In Catalan).

Chambers, E., Lee, J., Chun, S., & Miller, A. E. (2012). Development of a lexicon for commercially available cabbage (baechu) kimchi. *Journal of Sensory Studies*, *27*, 511–518. https://doi.org/10.1111/joss.12015

Chun, S., Chambers, E., & Han, I. (2020). Development of a sensory flavor lexicon for mushrooms and subsequent characterization of fresh and dried mushrooms. *Food*, *9*(8), 980. https://doi.org/10.3390/foods9080980

Commission Regulation (EC) No 1241/2002, 2002 Supplementing the Annex to Regulation (EC) No 2400/96 on the entry of certain names in the Register of protected designations of origin and protected geographical indications provided for in Council Regulation (EEC) No 2081/92 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs (Gailtaler Speck, Morbier, Queso Palmero or Queso de la Palma, Thrapsano extra virgin olive oil, *Turrón de Agramunt* or *Torró d'Agramunt*). Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2002:181:FULL&from=ES.

Drake, M. A., & Civille, G. V. (2002). Flavor lexicons. *Comprehensive Reviews in Food Science and Food Safety*, *2*, 33–40.

Flandrin, J.L. & Montanari, M. (2011). *Historia de la Alimentación*. (2nd ed). Editorial Trea.

García-García, E., Narbona, E., Jurado, P., Burló, F., Roche, E., & Carbonell-Barrachina, A. A. (2012). Volatile composition of "a la piedra" turrón enriched with royal jelly. *Italian Journal of Food Science*, *24*, 132–139.

Hartel, R. W., & Hartel, A. (2014). *Candy bites: The science of sweets*. New York, NY: Springer.

Hojjati, M., Speziale, M., Noguera-Artiaga, L., & Carbonell-Barrachina, A. A. (2015). Volatile composition, texture and sensory description of Gaz (traditional Persian confection). *Journal of Texture Studies*, *46*, 440–454. https://doi.org/10.1111/jtxs.12143

ISO (2007) Standard 8589: Sensory analysis. General guidance for the design of test rooms.

ISO (2010). Standard 5492: Sensory analysis. Vocabulary.

ISO (2012). Standard 8586: Sensory analysis. General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors.

ISO (2013). Standard 3972: Methodology. Method of investigating sensitivity of taste.

ISO (2019). Standard 20613: General guidance for the application of sensory analysis in quality control.

Jaffe, T. R., Wang, H., & Chambers, E. (2017). Determination of a lexicon for the sensory flavor attributes of smoked food products. *Journal of Sensory Studies*, *32*(3), e12262. https://doi.org/10.1111/joss.12262

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food* (2nd ed.). New York, NY: Springer.

Lawless, L., Jr., & Civille, G. V. (2013). Developing lexicons: A review. *Journal of Sensory Studies*, *28*, 270–281.

Lea, P., Næs, T., & Rodbotten, M. (1998). *Analysis of variance for sensory data* (2nd ed.). New York: John Wiley and Sons.

London Economics (2008). Evaluation of the CAP policy on protected designations of origin (PDO) and protected geographical indications (PGI). Retrieved from https://londoneconomics.co.uk/blog/publication/evaluation-of-the-cap-policy-on-protected-designations-of-origin-pdo-and-protected-geographical-indications-pgi/.

MAPA (Ministerio de Agricultura, Pesca y Alimentación) (2002). Pliego de condiciones de la Indicación Geografica Protegida *Torró d'Agramunt*. Retrieved from https://www.mapa.gob.es/es/alimentacion/temas/calidad-diferenciada/Pliego_condiciones_tcm30-209916.pdf.

Martínez-Navarrete, N., Fito, P., & Chiralt, A. (1996). Influence of conditions of manufacture and storage time on the textural characteristics of Xixona turrón. *Food Control*, *7*(6), 317–324. https://doi.org/10.1016/S0956-7135(96)00062-X

Narbona, E., García-García, E., Vázquez-Araújo, L., & Carbonell-Barrachina, A. A. (2010). Volatile composition of functional 'a la Piedra' turrón with propolis. *International Journal of Food Science and Technology*, *45*, 569–577. https://doi.org/10.1111/j.1365-2621.2009.02167.x

Neugebauer, A., Granvogl, M., & Schieberle, P. (2020). Characterization of the key odorants in high-quality extra virgin olive oils and certified off-flavor oils to elucidate aroma compounds causing a rancid off-flavor. *Journal of Agriculture and Food Chemistry*, *68*(21), 5927–5937.

O'Mahony, M. (1985). *Sensory evaluation of food*. New York: Marcel Dekker, Inc.

OJEU. (2012). Regulation (EU) no 1151/2012 of the European Parliament and of the council of 21 the November 2012 on quality schemes for agricultural products and foodstuffs. *Official Journal of the European Union*, *343*, 1–29.

Pérez-Elortondo, F. J., Ojeda, M., Albisu, M., Salmerón, J., Etayo, I., & Molina, M. (2007). Food quality certification: An approach for the development of accredited sensory evaluation methods. *Food Quality and Preference*, *18*(2), 425–439.

Pérez-Elortondo, F. J., Symoneaux, R., Etaio, I., Coulon-Lery, C., Maître, I., & Zannoni, M. (2018). Current status and perspectives of the official sensory control methods in protected designation of origin food products and wines. *Food Control*, *88*, 159–168.

Pérez-Elortondo, F. J. & Zannoni, M. (2021) *Guidelines for sensory analysis of protected designation of origin food products and wines*. Zaragoza. Ed. Acribia to European sensory science society (Available from https://www.e3sensory.eu/).

Speziale, M., Vázquez-Araújo, L., Mincione, A., & Carbonell-Barrachina, A. A. (2010a). Volatile composition and sensory analysis of Italian gianduja torrone. *Journal of the Science of Food and Agriculture*, *90*, 1605–1613. https://doi.org/10.1002/jsfa.3987

Speziale, M., Vázquez-Araújo, L., Mincione, A., & Carbonell-Barrachina, A. A. (2010b). Volatile composition and descriptive sensory analysis of Italian vanilla torrone. *International Journal of Food Science and Technology*, *45*, 1586–1593. https://doi.org/10.1111/j.1365-2621.2010.02307.x

Vázquez, L., Verdú, A., Miquel, A., Burlo, F., & Carbonell-Barrachina, A. A. (2007). Changes in physico-chemical properties, hydroxymethylfurfural and volatile compounds during concentration of honey and sugars in Alicante and Jijona turrón. *European Food Research and Technology*, *225*, 757–767. https://doi.org/10.1007/s00217-006-0479-6

Vázquez-Araújo, L., Chambers, D., & Carbonell-Barrachina, A. A. (2012). Development of a sensory lexicon and application by an industry trade panel for turrón, a European protected product. *Journal of Sensory Studies*, *27*, 26–36. https://doi.org/10.1111/j.1745-459X.2011.00364.x

Vázquez-Araújo, L., Pérez-Castejón, L., Verdú, A., & Carbonell-Barrachina A. A. (2005). Reclutamiento, selección, entrenamiento y validación de un panel de catadores especializado en turrón y sus materias primas. *Alimentación, Equipos y Tecnología*, September, pp. 92–98 (In Spanish).

Vázquez-Araújo, L., Verdú, A., & Carbonell-Barrachina, A. A. (2008). Aroma volatiles of 'a la Piedra' Turrón. *Flavour and Fragrance Journal*, *23*, 84–92. https://doi.org/10.1002/ffj.1857

Vázquez-Araújo, L., Verdú, A., Enguix, L., & Carbonell-Barrachina, A. A. (2008). Investigation of aromatic compounds in Alicante and Jijona turrón. *European Food Research Technology*, *227*, 1139–1147. https://doi.org/10.1007/s00217-008-0829-7

Vázquez-Araújo, L., Verdú, A., Murcia, R., Burlo, F., & Carbonell-Barrachina, A. A. (2006). Instrumental texture of a typical Spanish confectionery product Xixona Turrón as affected by commercial category and manufacturing company. *Journal of Texture Studies*, *37*, 63–79.

Verdú, A., Serrano-Megías, M., Vázquez-Araújo, L., Pérez-López, A., & Carbonell-Barrachina, A. A. (2007). Differences in Jijona turrón concepts between consumers and manufacturers. *Journal of Science and Food and Agriculture*, *87*, 2106–2111. https://doi.org/10.1002/jsfa.2972

How to cite this article: López-Mas, L., & Romero del Castillo, R. (2021). Sensory analysis of nougat: Methodology, training, and validation of a panel for protected geographical indication *Torró d'Agramunt*. *Journal of Sensory Studies*, e12722. https://doi.org/10.1111/joss.12722

APPENDIX: TASTING SCORE SHEET FOR PGI *TORRÓ D'AGRAMUNT* NOUGATS

Name and surname: Date:

Color

Definition: sensation of hue, saturation, and lightness induced by stimulation of the retina by light rays of various wavelengths.
Reference: photographs of four nougats for each of the two shapes (round disk and rectangular bar) in order of their color intensity (from low to high).
Procedure: Write down the code of the sample and mark reference picture that it most closely resembles with a cross. Repeat the same procedure for each sample.

Round disk nougat

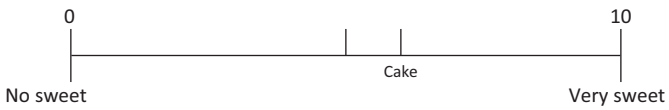
Sample	Picture 2	Picture 3	Picture 4	Picture 5

Rectangular bar nougat

Sample	Picture 2	Picture 3	Picture 4	Picture 5

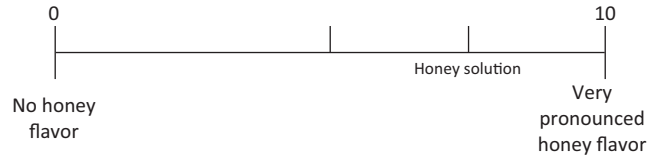
Sweetness

Definition: basic taste produced by dilute aqueous solutions of natural or artificial substances such as sucrose or aspartame.
Reference: cake score 6.
Procedure: introduce a sample in your mouth, chew it until it becomes a paste, move it around your mouth, and swallow it; then assess its sweetness on the intensity scale. Repeat the same procedure for each sample.



Honey flavor

Definition: perception of honey flavor, with all the aromatic compounds that it can give off.
Reference: honey solution score 7.5.
Procedure: introduce a sample in your mouth, chew it until it becomes a paste, move it around your mouth, and swallow it; then assess its honey flavor on the intensity scale. Repeat the same procedure for each sample.



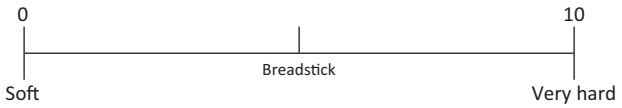
Crunchiness

Definition: a descriptor related to cohesiveness and hardness and to the force necessary to break a product into crumbs or pieces.
Reference: raw carrot.

Procedure: introduce a sample in your mouth and crush it between your molars; evaluate its crunchiness on the intensity scale by comparing the noise you hear with the reference. Repeat the same procedure for each sample.

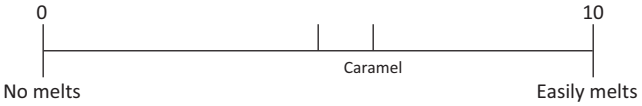
Hardness

Definition: attribute related to the force required to achieve a given deformation, penetration, or breakage of a product.
Reference: breadstick.
Procedure: introduce a sample between your molars, clamp down on it carefully until it breaks; evaluate the force required on the intensity scale. Repeat the same procedure for each sample.



Fusibility

Definition: very low level of work required to masticate a solid product into a state ready for swallowing.
Reference: honey hard candy.
Procedure: introduce a sample in your mouth, move it around, without chewing it. After 20 s, assess the ease with which it has melted on the intensity scale. Repeat the same procedure for each sample.



Bitterness

Definition: basic taste produced by dilute aqueous solutions of various substances such as quinine or caffeine.
Reference: bitter water solution.
Procedure: introduce a sample in your mouth, chew it until it becomes a paste, move it around and swallow it. Write down the code of the sample and indicate with a cross whether you have noticed the presence of any bitter taste. Repeat the same procedure for each sample.

	Code	Code	Code	Code
Absence of bitterness				
Slight presence of bitterness				
Presence of bitterness				

Rancidity

Definition: the presence of a distinct unpleasant odor and taste due to the chemical alteration of its compounds.
Reference: rancid nuts (smell).
Procedure: introduce a sample in your mouth, chew it until it becomes a paste, move it around, and swallow it. Write down the code of the sample and indicate with a cross whether you have noticed the presence of rancid flavor. Repeat the same procedure for each sample.

	Code	Code	Code	Code
Absence of rancid flavor				
Slight presence of rancid flavor				
Presence of rancid flavor				