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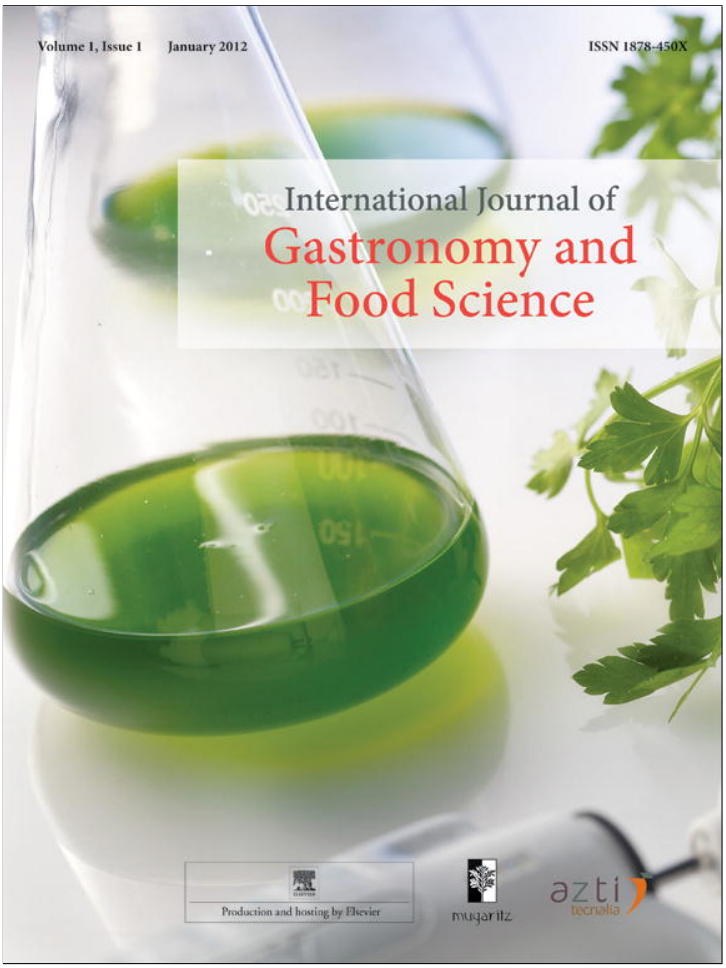

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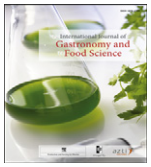

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Improvement of a culinary recipe by applying sensory analysis: Design of the New Tarte Tatin

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Abstract

During the last decade, knowledge of food science and technology has been applied to *Haute Cuisine* obtaining great benefits. The most important chefs of the world are keen on gaining knowledge about the physicochemical changes to food after any culinary process, as well as the art of combining different flavors in order to obtain both new flavors and new textures. This could allow chefs to develop new processes and hence gain a competitive advantage in their restaurants. Sensory analysis can be a good tool to develop new products in a restaurant, in particular, new desserts. Consumer response to the sensory properties of food (particularly appearance, flavor, aroma, taste and texture) is an important factor in determining the success of new products. Therefore, the aim of this work was to develop a new dessert, based on the classic French dessert "*Tarte Tatin*" (an upside down fruit tart, usually made with apples), using sensory analysis as a crucial tool in its design. The preference for different apple products prepared using different methods of cooking, was evaluated by a consumer panel and the statistical analysis showed significant differences ($a = 0.05$) between the processes.
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Keywords: Sensory analysis; Cook-vide; Sous-vide; Apple tart

Introduction

In the last few years, gastronomy has become an important feature of the socio-economic landscape of many countries. Its development is so important that there are more and more chefs who dedicate part of their professional activity to the investigation of new methods for preparing new foods with better sensory characteristics and at a fair price. Nevertheless, in the kitchen much is still based on empirical knowledge and there is little scientific knowledge of the culinary processes that underlie the quality of a gastronomic offering. To preserve quality over time, gastronomy should be standardized and based on the formal knowledge of chemistry and physics.

The most innovative trends developed by international chefs are based on methodologies and processes commonly used in investigative laboratories of Food Technology: the texture changes, flavors and aromas, time-controlled cooking, vacuum technology, supercritical extraction and other methods that have been applied for many years in research laboratories and in the food industry. The processes frequently used in the scientific arena and in the food industry are considered innovative by chefs. At present, culinary activity is a balance between tradition and technology, and the food technology knowledge that

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reaches the kitchen does so sporadically. Since 1988, Hervé This and Nicolas Kurti (Cassi and Bocchia, 2005) have been studying the physical and chemical processes that occur during the cooking of food. Thus, most gastronomy knowledge nowadays has been extrapolated from industrial processes, but always considering the unique connotations and peculiarities of a culinary preparation.

Over the past decades, chefs have introduced into their kitchens some tools and ingredients used by science and the food industry. Apart from the term used to describe this culinary movement, this "modernist cuisine" is characterized by the adoption of the scientific method to obtain new combinations of food and sophisticated culinary processes.

This new field is a combination of scientific knowledge about the physicochemical and technological properties of food and the experience of chef regarding culinary processes and recipes. This binomial 'scientific-kitchen' has resulted in new products and new combinations, new methods, techniques and tools that are used in the production process of foods (Barham et al., 2010).

The most important chefs of the world have a desire for the existing knowledge about the physicochemical changes that food undergoes after a culinary process and the art of combining different flavors in order to obtain new flavors and new textures, in this way they could develop new processes and gain a competitive advantage in their restaurants. Sensory analysis can be an important tool to develop and improve these new preparations. The responses of consumers to the sensory properties of food, particularly its appearance, flavor, aroma, taste and texture, are important factors in determining the acceptance of new products. In this way, the aim of this work was to develop a new preparation based on "Tarte Tatin", using sensory analysis as a design tool.

Materials and methods

Raw materials and sample preparation

For the present study, apples of the Granny Smith variety were used. They were acquired at a local market and were selected with the same dimensions and from the same batch. Granny Smith apples have a luminous green color, although some of them can have a pink skin. They are crunchy, juicy and acidic and so they are excellent to cook with and to eat raw. They are also fabulous in salads because the slices do not oxidize as rapidly as other types of apples. They have a stronger texture than other green apples which allows for infusions with better results. They are especially famous as one of the most commonly used apples for the production of apple pie and in general in other bakery products.

Here, the apples were peeled and cut in quarters and the seeds were removed. Then one of three processes was applied: for Sous-Vide (under vacuum), apples were vacuum packaged; for Cook-Vide (cooked in a vacuum), apples were placed without previous packaging directly inside a Gastrovac® basket (Fig. 1) and for Moist Heat, apples ( ) were placed inside an oven programmed to 100% humidity (at atmospheric pressure).

In the first test, the apples were cooked in Sous-Vide to a temperature of 75 °C for three different lengths of time: 90, 120 and 150 min. In the second test, three different cooking treatments (Sous-Vide, Cook-Vide and Moist Heat) at 75 °C for 120 min were evaluated. Once the cooking treatments were finished, the apples were packed in vacuum bags and cooled rapidly. Finally, sensory evaluation of the prepared samples was performed.

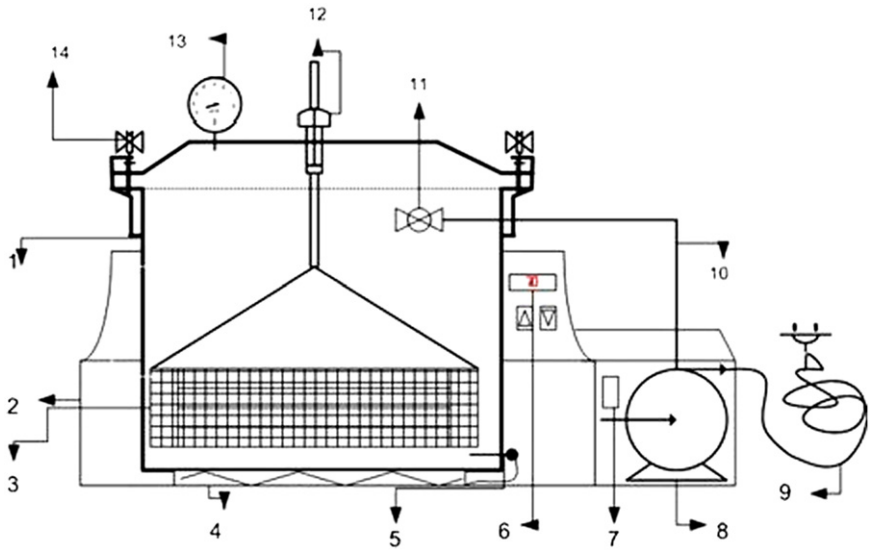

Fig. 1. Equipment for vacuum cooking (Gastrovac).

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Equipment

The samples were cooked in vacuum conditions (Sous-Vide), in conditions of continuous vacuum but without packaging (Cook-Vide) and at atmospheric pressure (Moist Heat). To cook in Sous-Vide and Cook-Vide, the Gastrovac® was used. This equipment has two principal elements, the body and the pot (Fig. 1). The body has the heating element, the vacuum and a temperature control system. The pot has a connection for the vacuum pump. To cook in conditions of Sous-Vide the same equipment was used but with the pump disconnected and the product previously vacuum packaged.

For Moist Heat cooking, a Rational oven (Selfcooking Center 102, Rational AG, Germany) was used. After each treatment, samples were placed into a Blast Chiller AMX 3—CHEF (Sincold, Treviso, Italy) at +3 °C for 40 min to decrease the temperature of the food and stop the cooking process. This equipment not only reduces the temperature of a food rapidly but it also preserves the physical characteristics and reduces the risks of bacterial proliferation.

Sensorial analysis

The consumers of the different apple products were young-adults between 18 and 45 year old who were asked to rate the overall acceptability and organoleptic quality of the previously described products. The tests took place in individual cabins and consisted of tasting and filling out score sheets. Two different procedures were used to compare the products and to determine if one was preferred. In procedure 1, there were 41 participants and in procedure 2, 42; according to AENOR (2009), these numbers are adequate to represent a consumer population.

A paired multi-comparison test and a preference test based on the model of Meilgaard et al. (1999) were the two procedures used. The results of this experimental design allow the panel of consumers to state their preference between two samples and to compare three pairs of samples simultaneously. Each participant tasted six pairs of samples within the analysis session. Three of them were evaluated for the comparison test of attributes and three evaluated for the preference test.

In the comparison test, color, aroma, texture, taste, appearance and preference were evaluated by the sensory panel. The purpose of the test was to choose an optimal cooking time for apples using the Sous-Vide heat treatment. In the preference test, the cooking time which was found optimal in the previous test was used to evaluate the same product attributes under the three different cooking conditions always at 75 °C: Sous-vide, Cook-vide and Moist Heat.

Statistical analysis

Non-parametric multiple comparisons using a Friedman pairwise ranking test (Meilgaard et al., 1999) and correspondence analysis were used to analyze the data from the sensorial analyses. The Friedman test is for comparing three or more related samples and makes no assumptions about the underlying data distribution.

In order to check rates of preference based on results from sample attributes, a correspondence analysis (CA) was performed. Statistical analyses were conducted with SPSS, version 16.0.

Results

This section describes the results from the two sensorial analyses: the aim of the first was to choose the best cooking time for apples using the Sous-Vide heat treatment, and the second was to select the best heat treatment amongst Sous-Vide, Cook-Vide and Moist Heat. In this test, the temperature was 75 °C and the cooking time was that chosen by the participant in the first test. In both tests, choices were influenced by individual preferences for the different attributes.

Sensory analysis to assess the optimal cooking time in Sous-Vide treatment

The data were obtained from the questionnaires described above. Fig. 2 shows the results obtained from the paired multi-comparison test for attributes and preferences.

In order to compare all the samples at the same time, the following statistical analysis was performed.

Friedman test and ranks sum

The sample rank sum was calculated. This score is the result of the addition of twice the sum of the frequencies of the columns to the sum of the frequencies of the rows for each treatment. The Friedman test was used to verify significant differences between the samples according to the attributes and the preference stated.

The statistic of Friedman test for each sample is compared with the statistic of chi-square (χ^2) with 2 degrees of freedom

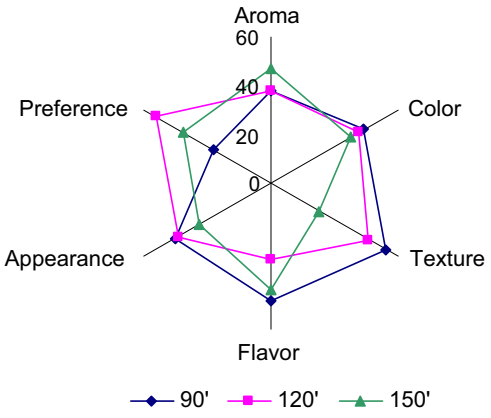

Fig. 2. Representation of the total sum of the values obtained by all the consumers for each attribute evaluated at each of three cooking times (n=41).

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Table 1
T Friedman values for the attributes analyzed. This value compares the perceived differences in attributes at three different cooking times.

Attributes	T Friedman
Aroma	1.8
Color	1.4
Texture	14.9*
Flavor	5.5
Appearance	2.4
Preference	9*

*Significant difference at $\alpha=0.05$.

Table 2
Difference between the rank sums in the formulations studied. This value compares the perceived differences in attributes between two cooking times.

Attributes	90–120′	90–150′	120–150′
Aroma	0	9	9
Color	3	9	6
Texture	7	29*	22*
Flavor	18	6	12
Appearance	1	11	10
Preference	16	7	23*

*Significant difference between the two cooking times at $\alpha=0.05$.

(5.99) and $\alpha=0.05$. Table 1 presents the Friedman test statistic for each attribute. A significant difference was observed for texture and preference in the samples evaluated.

In order to evaluate differences between specific cooking times, the Friedman test was followed by specific comparisons using Tukey's Honestly Significant Difference (HSD) multiple comparison post-hoc statistical test (Meilgaard et al., 1999).

In this case the value of q tabulated for 2 degrees of freedom and a significance level of $\alpha=0.05$, is 3.31. The HSD value obtained was 18.35. To compare between the different pairs offered to consumers, a table of rank sum differences was prepared (Table 2). The differences were compared with the value of HSD and were significant when this value was exceeded.

As shown in Table 2, significant differences were established for the attribute 'texture' between the samples cooked for 90 min and those cooked for 150 min, also between samples cooked for 120 min and those cooked for 150 min. Consumers did not find a significant difference between the samples cooked for 90 versus 120 min. The other attributes studied in the sensory analysis were not influenced by the length of the heat treatment. There was however a significant difference in preference between samples cooked for 120 min and those cooked for 150 min, with later analysis showing that the 120 min cooking time was preferred.

Table 3
Percentage of variability explained by the factors of correspondence analysis.

Factor	% Explained	% Accumulated
1	85.7	85.7
2	14.3	100

Table 4
Contributing factors to the inertia of the cooking times.

Treatment	Factor 1	Factor 2	Factor sum
90′	0.626	0.374	1
120′	0.665	0.335	1
150′	1	0	1

Table 5
Contributing factors to the inertia of each attribute.

Attributes	Factor 1	Factor 2	Factor sum
Aroma	0.644	0.356	1
Color	0.374	0.626	1
Texture	0.86	0.14	1
Flavor	0.007	0.993	1
Appearance	0.771	0.289	1
Preference	0.629	0.371	1

Correspondence analysis

A correspondence analysis was performed in order to determine the relationships among the different treatment times and the attributes of the apples. This analysis showed that two factors accounted for 100% of the variability of the data (Table 3), thus the attributes and the different treatments were well represented along the factorial plane.

The data presented in Tables 4 and 5 show that the formulations and attributes are well represented along the first two factors, since the sum of the relative contributions of these two factors in relation to each formulation were high. Therefore, the most relevant results of sensory analysis performed can be deduced from the study of the projection on the factorial plane shown in Fig. 3.

Fig. 3 shows the projection of the attributes and the treatments evaluated in a factorial plane. According to the distribution of attributes in the plane, it can be seen that the sample preferred by the consumers was the one cooked for 120 min. Although these differences did not reach significance, the most aromatic samples were apparently those cooked for 150 min, but the better color and better taste were apparently found in samples cooked for 90 min. Consumers did find significant differences among the cooking times for the texture attribute, however they did not consider it important when they chose the preferred

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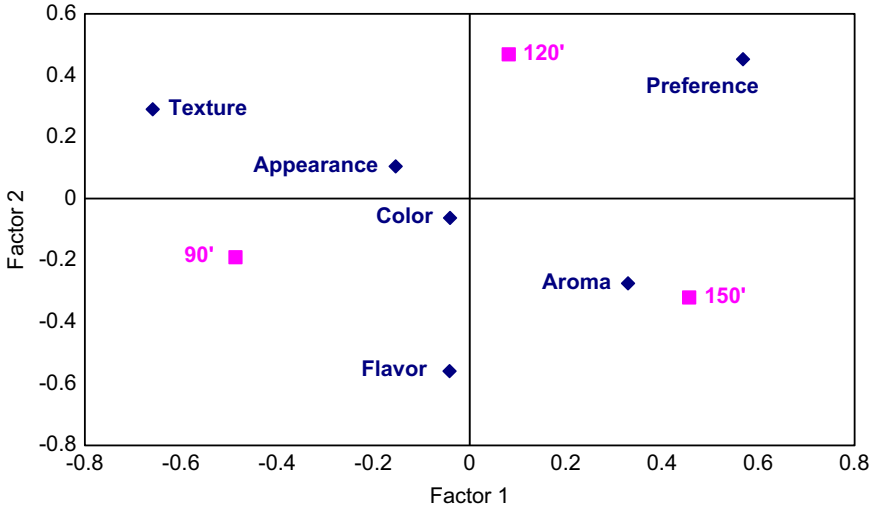

Fig. 3. Correspondence analysis. Representation on the factorial plane of the attributes selected (diamonds) and the evaluated treatments (squares).

sample. The same behavior is observed for the attribute of the samples "best appearance".

In summary, the results of the first sensory analysis show that consumers chose the samples cooked for 120 min using the Sous-Vide process and the choice was not based on preference for a particular attribute. The only significant difference found between cooking times applied to the attribute 'texture', although consumers did not attach much importance to this attribute when selecting their preferred sample. Therefore, it was decided to set the cooking time to 120 min for the second study.

Sensory analysis to evaluate the cooking treatment

Here, a heat treatment was applied at 75 °C for 120 min (as selected above) and three cooking methods were analyzed: Sous-Vide (vacuum-packed), Cook-Vide (unpacked product cooked under vacuum conditions) and Moist Heat (Heat Treatment at atmospheric pressure) .

Fig. 4 shows the preference of the consumers for the different samples based on the attributes tested.

Below are the statistical analysis used to compare the samples.

Friedman test and ranks sum

The results of total rank sums obtained for all the attributes were subjected to Friedman's test as for study 1 comparing cooking times. The values obtained are shown in Table 6 and compared with tabulated statistical values of χ^2 with 2 degree of freedom (5.99 with a significance level of $\alpha=0.05$). The table shows that consumers found significant differences for aroma, color, flavor, appearance and preferred sample, since the calculated T value for each of those attributes was greater than the tabulated value of χ^2.

Again as in test 1, the Tukey Honestly Significance Difference (HSD) method of post-hoc multiple comparison tests were performed between samples to identify

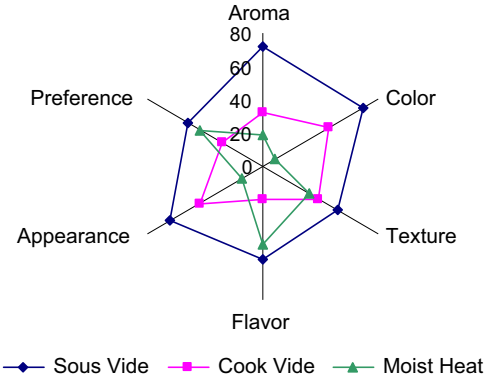

Fig. 4. Representation of the total sum of the values obtained by all consumers for each attribute evaluated for each of the three cooking methods ($n=42$).

Table 6
T Friedman values for the attributes analyzed.

Attributes	T Friedman
Aroma	50.5*
Color	60.3*
Texture	5.5
Flavor	22.8*
Appearance	41.4*
Preference	8.39*

*Significant difference at $\alpha=0.05$.

significant differences (Meilgaard et al., 1999). In this case the q value was tabulated for 2 degrees of freedom and at a confidence level of $\alpha=0.05$ the value was 3.31. The HSD value obtained was 18.35, the same as in the first study. To compare between the different pairs offered to consumers, a rank-sum table of differences was made (Table 7). The differences were compared with the value of HSD and were significant when this value was exceeded.

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Table 7
Difference between the rank sums for the heat treatments studied.

Attributes	Sous Vide–Cook Vide	Sous Vide–Moist Heat	Cook Vide–Moist Heat
Aroma	39*	54*	15
Color	21*	60*	39*
Texture	12	18	6
Flavor	36*	9	27*
Appearance	19*	50*	31*
Preference	21*	3	18

*Significant difference at $\alpha = 0.05$.

Fig. 5. New Tarte Tatin designed by the chef Jorge Bretón Prats.

Significant differences were established for the attribute 'aroma' between Sous-Vide and Cook-Vide samples and also between Sous-Vide and Moist Heat (Table 7). Consumers found significant differences in the attributes of 'color' and 'appearance' among all three treatments. For the attribute 'texture', in contrast with the first study in which cooking temperature did affect this parameter, it is observed that the type of cooking either did not affect the samples or consumers were not able to appreciate the difference. The preferred sample was the Sous-Vide cooking treatment as shown in Fig. 4. Unlike in study 1 on cooking times, the choice of preferred sample also corresponds to a higher score for this treatment on all attributes analyzed.

Once the ideal cooking time (120 min) and the optimal heat treatment (Sous-Vide) were found, the chef Jorge Bretón Prats proceeded to design the New Tarte Tatin Fig. 5 shows the result obtained in the design of the dish.

Recipe

Ingredients

- *Granny Smith* apples.
- Puff pastry.
- Sirup 1:1 (one part water per one part sugar).
- Pastry cream with cinnamon and vanilla.
- Ice cream of cooked apples.

Equipment

- *Parisien*.
- Gastrovac.
- Vacuum bags.
- Oven.

Preparation

1. Peel the apples and make spheres of different sizes with a Parisien, place them in a vacuum bag with the sirup.
2. Vacuum infused apples with the sirup and let stand for 5 min. Break the vacuum and repeat the procedure until the apples are visually completely infused.
3. Cook the apples in Sous-Vide for 120 min at 75 °C. Refrigerate or place in the blast chiller.
4. Bake the puff pastry in the oven for 5 min on waxed paper and cut into strips of $15 \times 2 \times 2$ cm^3.
5. Placed the spheres, the puff pastry, the pastry cream and the ice cream over a plate as shown in Fig. 5.

Conclusions

The present study shows the use of the pairwise ranking in a study of culinary preferences. This experimental design is a structured method for ranking a small list of items in priority order and can help to make decisions in a consensus-oriented manner.

The results of the first sensory analysis showed that consumers chose samples cooked in a Sous-Vide process for 120 min and the choice was not based on preference for a particular attribute. The only significant difference found between treatments applied to the attribute 'texture', although participants did not attach much importance to this attribute when selecting the preferred sample. In the

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second sensory analysis, consumers preferred the Sous-Vide treatment over the two other cooking methods and here, the preference was closely related to individual attributes. These results allowed an improvement in the organoleptic quality of the cooked apple in the design the "New Tarte Tatin" by the chef Jorge Bretón (One Michelin star Restaurant *La Sucursal*). Similar studies on other dishes can likewise be used to allow organoleptic improvement based on scientific analysis.

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