RESEARCH ARTICLE

Validation of the incorporation of emotional response in consumer-based sensory development: case study in Peruvian craft beers

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Abstract

It is important to identify the emotional response and sensorial needs of consumers to get commercial success of the alimentary sector in order to improve the consumption experience. Obtaining attractive characteristics through the application of the Kano model allows increase the consumer satisfaction. Furthermore, the *Napping®-Ultra Flash Profile* (UFP) methodology makes it possible that producers of craft beers may well reliably characterize their products. Likewise, the use of External Preference Mapping (EPM) allows the identification of those highly accepted products. In this sense, the goal of the present study was to validate, through the application of EPM, that the incorporation of the Kano model in the sensory design increases consumer satisfaction in turn obtaining the sensory profile of Peruvian craft beers. The Kano model permitted to determine the attractive characteristics of representative craft beers of the Lima market: the presence of exotic fruits, fruity smell, presence of Andean cereals and high alcoholic grade, and, based on these characteristics, a prototype of craft beer was developed. By using *Napping®*-UFP, consumers positioned and described the six samples of Peruvian craft beers (five commercial brands and the prototype), we found that the prototype developed showed floral smell, herbal odor, fruity smell, light golden color, bubbly, exotic fruits, and high alcoholic grade. The EPM showed that 80% of consumers scored the prototype with a high grade of taste. Finally, putting together these techniques turns out to be useful in obtaining products that are highly accepted by the consumer and this methodology could be applied to other products.

Keywords: craft beer; Kano model; external preference mapping; Napping®-Ultra Flash Profile.

1. Introduction

In recent years, the study of the consumer emotional response when interacting with food has increased, since it is known that this significantly influences its final acceptance (Mora et al., 2019). For this reason, a trend has been generated that seeks to study the emotional behavior of the consumer caused by products in general such as Kansei engineering, the EsSense Profile® or the Kano model. Professor Noriaki Kano (Kano et al., 1984) developed the Kano model, which is a technique used to select attribute characteristics that deserve to be included during product development, so that their presence increases consumer satisfaction. This model allows to classify the quality characteristics of a product in the following categories: attractive, one-dimensional, must be, indifferent and inverse (Meilgaard et al., 2016), and clearly shows the elements that developers must consider to guarantee acceptability of the product. This technique would result in a very versatile alternative when integrated as an initial step in sensory development to know in advance what the consumer would expect to feel when interacting with food, with which the producer could focus their efforts on generating formulations that meet these emotional needs (Chen & Su, 2006; Matzler et al., 1996). It is worth mentioning that this technique has been used successfully in the development of meat products, such as hot dogs (Puma-Isuiza & Núñez-Saavedra, 2018) and bakery products, such as gluten-free brownies (Liñan-Pérez, 2019).

In addition, sensory evaluation by consumers has become a topic of research in sensorial sciences in the past twenty years. There is now more scientific

evidence that consumers can provide descriptive, valid, and significant sensorial information (**Ares et al., 2015**; **Bruzzone, 2014**; **O'Sullivan, 2017**; **Varela & Ares, 2014**). This provides a solution to the problems observed at food industries and, can be used as a tool for the development and characterization of products accepted by consumers (**Varela & Ares, 2014**). Several methodologies have been developed which can be applied for the development of new products from information about the taste, preferences, and consumers' needs. One of them is *Napping®*, this is a technique originated from market research, where the samples are grouped by subjects in typical paper sheets of A2, A3, A4 or 60 x 60 cm^2 sizes (**Oliver et al., 2018**; **Pagès, 2005**; **Perrin et al., 2008**). The *Napping®-Ultra Flash Profile* (UFP) adds a descriptive component to the mapping process (**Mayhew et al., 2016**; **Perrin & Pagès, 2009**; **Santos et al., 2013**) that not only allows to differentiate the samples according to their (dis)similarities, but also to characterize them sensorially using a vocabulary that the consumer can perceive and understand, this technique has been successfully applied in the characterization of alcoholic beverages (**Louw et al., 2013**). Furthermore, the external preference mapping allows to investigate the consumers' affective response, through spatial representation (**Lawless & Heymann, 2010**), where it is possible to appreciate the segmentation of the products in limits that demarcate the percentage of consumers who indicate that they felt a high satisfaction when evaluating the product.

Beer is one of the most ancient alcoholic drinks human beings have produced and it is also the most consumed in the world, in 2021 over 186 billion liters of beer were consumed worldwide (**Barth-Haas Group, 2021**). Consumption per capita of "industrial" beers in Peru grew from 32.4 to 46.9 liters per person between 2007 and 2016 (**Euromonitor International, 2019**). Beer is made with four ingredients: water, malt, hops and yeast (**Machado et al., 2023**). However, these beers have not completely satisfied current consumers, who are seeking for better experiences. Consequently, craft beers have emerged, and beer drinkers are particularly interested in trying these new beers with different tastes, aromas, etc., instead of the current commercial brands (**Aquilani et al., 2015**). At present, instrumental analysis, as well as sensory analysis, can be used to evaluate the quality of beers. However, craft breweries tend to use only the instrumental methods such as percentage of the original wort, quantity of alcohol, pH, degree of bitterness or color. This is mainly because they are considered more objective and because there is

poor innovation in the characterization of beers, from a sensorial point of view. It is important to mention that the sensory evaluation in beers has had several applications such as: to study beer stability (**Lehnhardt et al., 2018**), to explore the effects of the labels, alcohol content and beer sensory descriptors on hedonic properties (**Blackmore et al., 2022**), to evaluate the influence of specialty malts on the sensory profile of beer (**Prado & Gastl, 2023**) and to evaluate consumers' preferences when pairing them with other food (**Nijman et al., 2019**). In such investigations, the classical descriptive analysis with trained judges has been used. For craft breweries, they could be considered as a luxury, due to the high costs needed to maintain a sensorial panel, which would be a discouraging factor in the development of craft beers.

For these reasons, the objective of this research was to validate, through the application of External Preference Mapping, that the incorporation of the Kano model in the sensory design of food increases consumer satisfaction in turn obtaining the sensory profile of Peruvian craft beers employees.

2. Methodology

2.1 Samples

2.1.1 Identification of representative craft beers from the Peruvian market

Samples of craft beer were selected from marketing research which allowed the creation of a database, to which a two-stage cluster analysis was applied to form homogeneous groups. The selection of commercial beer samples was done to guarantee enough variety, having a special ingredient, with a taste of interest, and with the presence of attractive characteristics obtained from the Kano questionnaire. The idea was to add complexity to the discriminative task of consumers. Selected samples and their quality characteristics, provided by producers of craft beer, are shown in **Table 1**.

2.1.2 Craft beer production

The style selected to produce the craft beer prototype was *Fruit Belgian Golden Strong Ale*, whose formula consists of Pilsen malt 80%, best caramel pils 5%, Cascade hop 0.5%, fuggles hop 0.5%, camu-camu pulp 7.5%, pomegranate pulp 6.4% and US-05 yeast 0.1%. During production, malt (*Pilsen* EBC 3.0 - 4.9 and *Caramel Pils* EBC 3 - 7 from Bestmaltz) was ground using a roller grinder (VZ, R45 G), producing thick milling, which was then mixed with water and taken to the following temperatures: 52 °C for 20 minutes, 65 °C for 60 minutes and 72 °C for 20 minutes. Run-out grains were separated from wort by using a mesh filter.

Table 1
Grouping and characteristics of commercial craft beers

Group obtained from the two-stage cluster	Beer name	Style	Quality characteristics
Group 1: Reddish beers	Gran Puka	Irish Red Ale	5.5% Alc. Vol., malted-sweet flavour, herbal aroma, IBU 20 SRM 18
Group 2: Black beers	Maillard	British Brown Ale	5.5% Alc. Vol. bitter-coffee flavour, earthy aroma, IBU 25 SRM 35
Group 3: Fruit beers	Kamacitra	Indian Pale Ale	4.5% Alc. Vol., bitter flavour, fruit aroma, IBU 30 SRM 7
Group 4: Golden beers	L.I.MA.	American Pale Ale	6.1% Alc. Vol., passion fruit-mango flavour, citric-fruit aroma, IBU 35 SRM 10
	Moche Loche	Loche Ale	6.1% Alc. Vol, bitter-malted flavour, spicy-earthy aroma, IBU15 SRM5

Sweet wort was taken to a marmite (Brewest best, 60 L). The wort boiling was made at a temperature close to 100 °C. Hop was added in three parts (*Cascade* AA 7.3% and *Fuggles* AA 5.9% of *An aroma hop*) after boiling started at 15, 40 and 50 minutes. Wort boiling lasted one hour. It was cooled until it reached a temperature of 20 to 25 °C, by using a plate exchanger (Wort Chiller, WC115) with a chiller (Keling, FM-65L).

On the other side, yeast (Safale US-05 of Fermentis) was activated. Activated yeast was added directly to the fermentation chamber (Speidel, 60 L), where the chilled wort was kept at a temperature of 20 to 25 °C. The wort was fermented from an initial density of approximately 1.080 to a final density of 1.010 g of sugar per mL of wort. This process lasted seven days, at a temperature of 20 to 25 °C. Then, the fermented wort was separated from the precipitated yeast. The fermented wort was transferred to barrels previously refrigerated (4-5 °C) for 10 days. Beer was bottled in 330 mL amber bottles. Two to three grams of sugar solution were added to each bottle. Then a bench capper (Colt Strong) was used to cover the bottles using crown type caps. Finally, the bottled beer was stored at room temperature (25 °C approximately), in a fresh environment, and far from sun rays.

2.2 Physicochemical characterization of beers

The physicochemical analysis was done at the Biotechnology lab of the Faculty of Food Industries at UNALM. Craft beer samples (representative ones and the prototype) were characterized in a physicochemical way; to do so, it was necessary to determine its pH value (**INACAL, 2016a**), soluble solids (**AOAC, 2016**), bitterness (BU) (**INACAL, 2016b**), alcoholic content (°GL) (**INACAL, 2015**) and color (EBC) (**INACAL, 2016c**).

2.3 Emotional – sensory methodology

The methodology used in the present investigation that incorporates the emotional response, through the Kano model, in the sensory development based on the consumer using the Napping® - UFP method and its validation through the EPM, is shown in **Figure 1**.
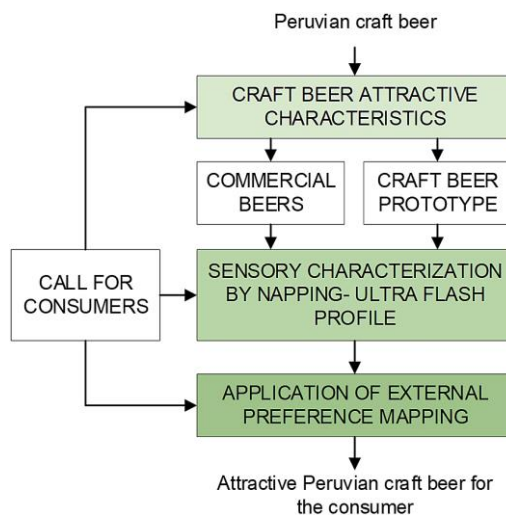

Figure 1. Scheme of the emotional-sensory methodology used in the development of attractive craft beer for the consumer.

2.3.1 Identification of attractive characteristics for consumers of craft beers

The Kano test was carried out at the university campus at UNALM facilities. The survey was composed of two questions for each of the eighteen attributes obtained from the literature. Some of them came from the sensorial features of the beer, such as flower aroma, fruit aroma, herbal aroma, bitterness, sweetness, astringency, burbling. Some appearance attributes were also included, such as light golden color, dark brown color, bubbly, murky and too foamy (**Giacalone, 2013**; **Meilgaard, Dalgliesh, & Clapperton, 1979**; **Simpson, 2016**).

The survey was carried out among 25 men and 22 women, with ages ranging between 18 and 27 years old. Twenty-four of them were undergraduate and graduate students at the Universidad Nacional Agraria La Molina, from different majors. The other twenty-three participants were craft beer consumers and enthusiastic people. The students were specially selected for their level of consumption of craft beer, or similar food, and their willingness to participate of the test. For the implementation, the methodology used was the one described by (**Sauerwein et al., 1996**).

2.3.2 Sensory characterization by Napping® - Ultra Flash Profile

This was carried out at craft resto-bars in the city of Lima, Peru. A total of 33 consumers participated: 19 men and 14 women, between 18 and 35 years old. Twenty-five of them were craft beer regular and enthusiastic consumers. The other eight were people with certain experience in craft beer market, producers, employees, and owners of companies dedicated to craft beer production. These participants were selected mainly due to their degree of craft beer consumption (Pagès, 2005; Varela & Ares, 2014).

Sensory characterization through the Napping®-UFP was carried out in two stages. In the first stage, corresponding to Napping® evaluation, recruited consumers received samples of craft beers (freshly served in translucent glasses and at a temperature of 5 - 7 °C) coded with three-digit random numbers and the evaluation card (40 x 60 cm), where they wrote down sample codes, so that, if two codes appeared together, it meant the samples were more similar. Otherwise, the opposite meant that samples had more differences (Pagès, 2005; Varela & Ares, 2014). In the second stage, referred as verbalization, consumers generated and wrote down on the same evaluation card, sensorial descriptions they perceived in each of the samples (Perrin et al., 2008).

2.3.3 Application of external preference mapping

For the EPM, 103 consumers were recruited who evaluated all the craft beer samples. Tests with consumers were carried out in craft beer resto-bars in Lima. The frequency of consumption of the craft beer, availability, and interest in participating in this study was considered by applying an exploratory survey. Samples were presented to recruited consumers along with an evaluation card, consisting of a nine-points scale. On such scale, value one was "I barely like it" and value nine "I like it a lot".

2.4 Statistical Analysis

A Principal Components Analysis (PCA) was applied over the average results (N=3) of the physicochemical characterization. In addition, groups of similar samples were identified through the Hierarchical Cluster Analysis generated over the first two dimensions of PCA.

Napping®-UFP data was processed with a Multiple Factorial Analysis (MFA), where each group defined in advance was created by the pair of coordinates (x, y) from each consumer. Columns of the frequency table of sensorial descriptors were projected as supplementary variables (Delarue, Lawlor, & Rogeaux, 2015; Le, 2015). To evaluate significant differences, confidence ellipses of

samples were built through Bootstrap Trunk Technology (Cadoret & Husson, 2013; Dehlholm et al., 2012). We worked with the MFA consensus index (Varela & Ares, 2014) to build the external preference map. PCA and the MFA were carried out with the package FactoMineR (Le & Husson, 2008), from Software R 3.5.1. All analyses were assessed at a p-value=0.05.

3. Results and discussion

3.1 Identification of attractive characteristics of craft beers

Kano's characteristics are classified as one-dimensional, attractive, indifferent, and must-be, in quadrants I, II, III, and IV, respectively (Llinares & Page, 2011). Classification of the 18 characteristics of Peruvian craft beers is shown in Figure 2.

Figure 2 shows the following characteristics: presence of exotic fruit (-0.02, 0.73), fruity smell (-0.05, 0.70), presence of Andean cereals (0.00, 0.64) and high alcoholic grade (-0.02, 0.50), which are considered attractive characteristics, as the satisfaction coefficient (SC) is higher than 0.50; which can be interpreted as follows: if the characteristics are present in the product, the satisfaction of the consumer is going to grow up; but, if they are not present, it does not generate dissatisfaction (dissatisfaction coefficient (DC) > - 0.50).
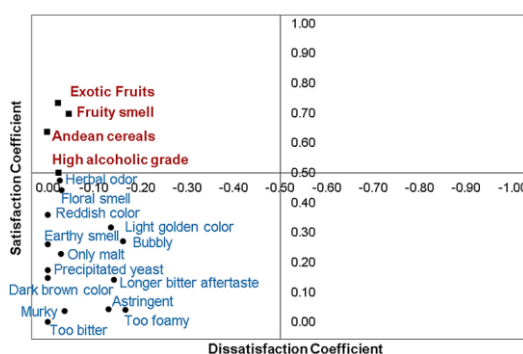

Figure 2. Representation of 18 characteristics of craft beers evaluated through Kano satisfaction (SC) and dissatisfaction (DC) coefficient.

Characteristics: herbal odor (-0.03, 0.47), floral smell (- 0.03, 0.44), reddish color (0.00; 0.36), light golden color (-0.14, 0.32), bubbly (-0.16, 0.27), earthy smell (0.00, 0.26), made only from malt (-0.03, 0.23), with precipitated yeast (0.00, 0.17), longer bitter aftertaste (-0.14, 0.14), dark brown color (0.00, 0.15), astringent (-0.13, 0.04), murky (-0.04, 0.04), too foamy (-0.17, 0.04) and too bitter (0.00, 0.00), are considered as indifferent characteristics, and can be eliminated without incurring in a negative impact that may be significant for the consumer satisfaction.

Following the results of the Kano model application, the attractive characteristics for Peruvian craft beer consumers are the presence of exotic fruits, fruity smell, presence of Andean cereals, and high alcoholic grade.

3.3 Sensory characterization of beer samples using *Napping*®-UFP

The Multiple Factorial Analysis (MFA) allowed the graphic representation of data generated in the Napping® stage and the stage of generation of sensorial descriptors (verbalization) of the craft beer samples, considering them as active and supplementary variables, respectively (**Kemp et al., 2018**; **Pagès, 2005**; **Pagès, 2003**; **Varela & Ares, 2014**). The MFA held 74.52% of variability in the first two dimensions. On that subject, **Perrin et al. (2008)** through the MFA, in his comparative study of classical and quick sensorial techniques in wine, applied the Ultra Flash Profile obtaining 59.79% of accumulated variability. Additionally, **Santos et al. (2013)** through the Generalized Procrustes Analysis (GPA) in his descriptive sensorial study with mortadella, applied the Ultra Flash Profile obtaining 84.58 % of accumulated variability in the two first dimensions. To determine if there are any significant differences between the craft beer samples, reliable ellipses (**Figure 3**) were built through the Bootstrap Total Trunk method, available in the package SensoMineR (**Le & Husson, 2008**), considering the two first dimensions of the MFA (**Cadoret & Husson, 2013**).

In **Figure 3** (left side), the creation of four groups of products that have been frequently categorized together is shown: LA and FBGSA samples are not significantly different because part of their confidence ellipses has overlapped paths. The same occurs between APA and IPA samples. On the contrary, IRA and BBA samples are different from all the other samples and were not grouped. **Antúnez et al. (2017)** applied the Bootstrap Total Trunk to generate confidence ellipses by comparing methodologies based on the consumer, for the sensorial characterization of four groups of samples of powder drinks; and the volatile composition and aromatic profile of the Tannat wines from Uruguay, respectively, which led to the creation of groups between similar samples.

In **Figure 3** (right side), the correlation circle of supplementary variables (descriptors) from the Multiple Factorial Analysis is shown under the *Napping*®-UFP context. This complementary information is essential to interpret the relative position of the samples, as this is normally not self-included in the *Napping*®. Therefore, it is necessary to complement the *Napping*® original information (products coordinates), with the comments that are requested to evaluators to be added to the samples, once they are included in the evaluation sheet. This stage has been named verbalization, literally to express thoughts, feelings, and emotions in words (**Delarue et al., 2015**).

About the correlation circle of sensorial characteristics of Peruvian craft beers evaluated with Napping®-UFP, the **Figure 3** shows that most vectors of sensorial descriptors have more correlations with the first dimension (vector X). The fact that the horizontal dimension is used more than the vertical dimension is a recurrent result in the *Napping*® test and it is supported by the fact that the evaluation sheet is a rectangle with a longer horizontal side (**Giacalone, 2013**). However, more frequent use of the horizontal dimension corresponds to a more significant sensorial dimension for the consumer; so that vectors X will correspond to the most important sensorial characteristic for the consumer (**Pagès, 2005**).
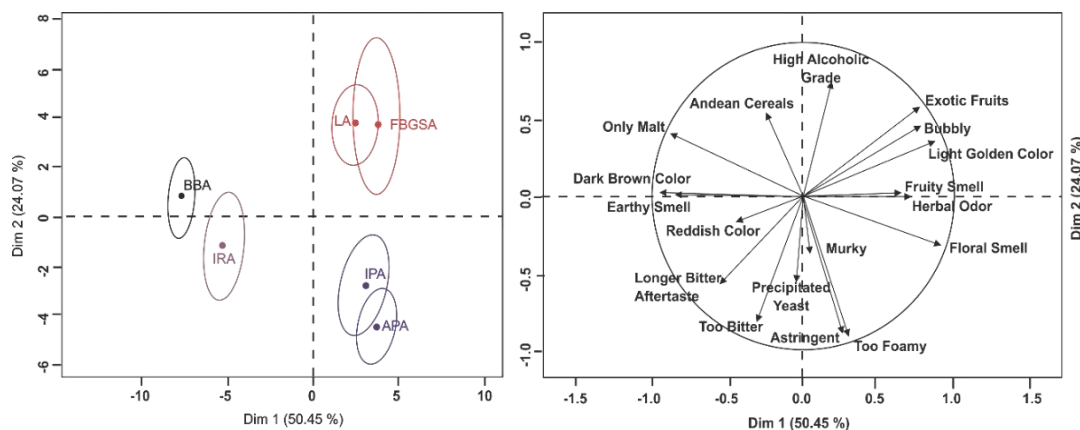

Figure 3. Results of the Napping® -UFP application. On the left: confidence ellipses of Peruvian craft beer samples. On the right: correlation circle of sensorial characteristics of Peruvian craft beers evaluated with *Napping*®-UFP (where IRA: Irish Red Ale, BBA: British Brown Ale, IPA: Indian Pale Ale, APA: American Pale Ale, LA: Loche Ale and FBGSA: Fruit Belgian Golden Strong Ale).

On the other hand, **Figure 3** shows the distribution of each sensorial characteristic generated in the verbalization stage; it is important to mention that these sensorial characteristics are generally treated as supplementary variables to the MFA in the *Napping®* coordinates.

Supplementary variables are not used to build the MFA model, however, correlation coefficients of these UFP characteristics are estimated and can be presented in the space of the product to help interpretation (**Giacalone, 2013**). This provides a sensorial configuration that is not necessarily propelled by more intense sensorial characteristics, but for those that are perceptibly more important for the consumer. Thus, some authors concurred that this method may produce quantitative as well as qualitative sensorial information (**Chollet et al., 2011**).

The sensory descriptors dark brown color, only malt, exotic fruits, bubbly, light golden color and floral smell have a high correlation ($r^2 > 0.95$) with the first dimension of the PCA, while the sensory descriptors too bitter, astringent and too foamy ($r^2 > 0.95$) , are better correlated with dimension 2 of the PCA, because they are close to the correlation circumference whose radius is 1, because the data were previously centered (**Escofier & Pagès, 1998**); However, the other sensory descriptors ($r2 > 0.60$) can also be used for the characterization of the products under study (**Kobayashi & Benassi, 2012**). It is observed that the positive side of dimension 1 is highly correlated with the characteristics of: herbal odor, fruity smell, light golden color, burbling, and exotic fruits; while its negative side is highly correlated with the characteristics of: only malt, dark brown color, earthy smell and reddish color. On the other hand, the positive side of dimension 2 is highly correlated with some characteristics, such as high alcoholic grade and presence of Andean cereals; and the negative side is highly correlated with longer bitter aftertaste, too bitter, astringent, precipitated yeast, and too foamy.

Finally, from **Figure 3** sensorial profiles of the evaluated samples of Peruvian craft beers can be obtained. IPA and APA samples were characterized mainly for the negative characteristics of dimension 2; it means that they are characterized for being too foamy, astringent, too bitter and to their longer bitter aftertaste. These characteristics are directly related to the amount of hop included in the formulation of this kind of beer. Besides, as per **Ferreira et al. (2005)**, bitter components that appear during the boiling of wort from precursors present in the hop, contribute to foam stability. Samples of beer LA and FBGSA were characterized mainly for the sensorial characteristics of the positive side of dimension 1;

that is floral smell, herbal odor, fruity smell, light golden color, bubbly and exotic fruits, while the positive side of dimension 2: high alcoholic grade and presence of Andean cereals. Same as IPA and APA styles, these characteristics are directly related to the composition of the beers. FBGSA beer presented fruit pulp in its formulation that provides exotic fruit taste. It also had aromatic hops that offer identified fruit, flower, and herbal notes, the same way as the processing that influenced the creation of these aromas. In the case of LA beer, the producer says they use "*zapallo loche*" (a type of squash) in its formulation, which has 9.93 °Brix (**Meneses, 2017**). Thus, this inclusion of pulp benefits the creation of alcohol and rebounds in the consumer perception of this sensorial characteristic in fruit craft beers. BBA and IRA beers were correlated mainly by sensorial characteristics of the negative side of dimension 1; it means, malted taste, dark brown color, earthy smell, and reddish color. These perceived sensorial characteristics are the result of the toasted malts used in the production of those types of beer. **Giacalone et al. (2013)** identified that beers type "Stout" and "Brown Ale" showed similar attributes as coffee and malt taste. In addition, these styles were grouped as dark beers; and sensorial descriptors correlated with these groups are consistent with the styles of beer to which they belong.

3.2 Physicochemical characterization of craft beer samples

Results obtained after the analysis of the main components of the parameters are shown in **Figure 4**. **Figure 4** shows that the characteristics of concentration of soluble solids (°Brix), alcoholic degree (°GL) and bitterness (°BU) are highly correlated with dimension 1 (horizontal axis) explaining 45% of the variability. On the other hand, the pH and color in EBC are highly correlated to dimension 2, explaining 26.5% of variability.
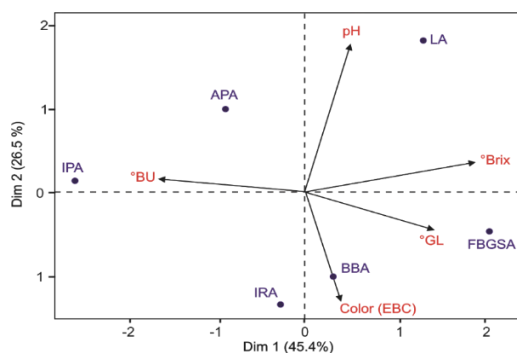

Figure 4. Analysis of main components of physicochemical parameters of Peruvian craft beers (where IRA: Irish Red Ale, BBA: British Brown Ale, IPA: Indian Pale Ale, APA: American Pale Ale, LA: Loche Ale and FBGSA: Fruit Belgian Golden Strong Ale).

The content of alcohol and Brix levels showed a high correlation with the positive side of PCA dimension 1 and both are highly correlated between themselves. The same happened with the formulated beer FBGSA, which showed the highest alcohol content (7.9 °GL). (Maeda & Andrade, 2003) in their investigation oriented to get an alcoholic drink made from camu-camu pulp, determined that this fruit has 5.6 °Brix and it allows to get drinks with a high content of alcohol. A study carried out by Martínez et al. (2017) about beer with fruit, also demonstrated that fruit addition in the production process allowed the production of beer with a higher content of alcohol.

In the same way, bitterness had a high correlation with the negative side of PCA dimension 1. Likewise, IPA and APA beers presented higher values of bitterness, because these styles contain a higher amount of hop that changes the concentration and proportion of compounds, with a bitter taste in the finished beer: from having isohumulinones (less bitter) to having a wide range of compounds derived as humulones, rusted humulones (humulinones), rusted lupulones and polyphenols, that provide a more bitter taste (Hahn et al., 2018).

In Figure 4, it can be observed that the pH had a high correlation with the positive side of PCA dimension 2 (vertical axis). Likewise, higher values of pH were found in LA and APA beers. Higher pH values are probably the result of beers where a *dry-hopping* method was applied (Maye, Smith, & Leker, 2016), where hop was added at several stages of the production process, even at the end of fermentation (Malowicki & Shellhammer, 2005). On the contrary, lower values of pH are seen in IPA, IRA, BBA, and FBGSA samples. In the case of the FBGSA sample, in which *dry-hopping* was carried out, the low value of pH was probably caused by the presence of fruit pulp in its formulation, as (De Azevêdo et al., 2014) pointed out, because the pH of camu-camu is found in a range of 2.62 and 2.44, which causes a decrease of the pH in wort.

As for color, this showed a high correlation with the negative side of PCA dimension 2. IRA and BBA beers presented the highest values of color in EBC units, because these styles have toasted malt in its formulation, such as roasted barley and melanoidin in the formulation of Irish Red Ale beers, as well as chocolate malt and black malt to produce British Brown Ale. These toasted malts are used in the production of beer to provide extra color and smell, and in relatively small amounts (normally < 5%) (Carvalho et al., 2016). This low percentage is the result of the use of lower levels of fermentable sugars and amino acids in the wort. Furthermore, its inclusion produces non-enzymatic brownish during the thermal processing of wort, which has a great impact on the color and taste of the beer due to the creation of Maillard reaction products (Coghe et al., 2014).

3.4. Evaluation of consumer satisfaction on craft beer samples through external preference mapping

Figure 5 shows the external preference map based on the two first dimensions of the MFA of the *Napping®*-UFP subjected to the hedonic scale through the Prefmap technique. The edge graphic shows lines corresponding to different percentages of consumers that graded general taste over the evaluated craft beers. The figure shows how many clusters show preference above the average, within an appointed region of the map of preferences.

In Figure 5, the external map shows that samples of APA and IPA craft beer were in an area where the percentage of consumers who liked them was 30 and 40 %. Those beer samples had a physicochemical characterization for high bitterness, and, in a sensorial way, they had lots of foam, were astringent, bitter, and had extended residual bitterness. This could mean that these characteristics are not pleasant for most consumers of craft beer from the city of Lima.

On the other side, the preferred samples were FBGSA, LA, BBA, and IRA, they were placed near the zones where the percentage of consumers who high graded general taste was 80, 70, 70, and 60 %, respectively. Samples of craft FBGSA and LA beer were grouped in the same cluster in a physicochemical and sensorial way. In the case of BBA and IRA samples, they were grouped only in a physicochemical way.
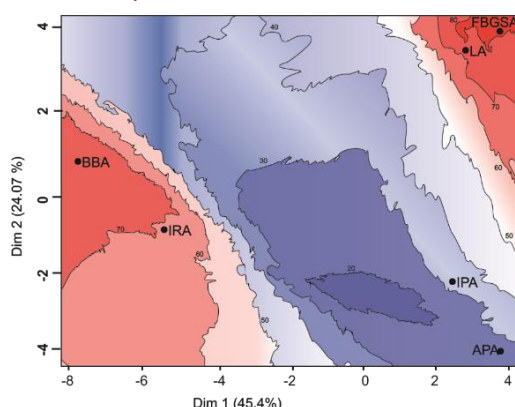

Figure 5. External Preference Mapping of Peruvian craft beer samples (where IRA: Irish Red Ale, BBA: British Brown Ale, IPA: Indian Pale Ale, APA: American Pale Ale, LA: Loche Ale and FBGSA: Fruit Belgian Golden Strong Ale).

The FBGSA sample was characterized mainly due to its content of alcohol and high °Brix, while the LA sample was due to high pH. Moreover, both were

characterized in a sensorial way for their flower aroma, herbal aroma, fruit aroma, golden color, burbling, presence of exotic fruit, high content of alcohol, and presence of Andean cereals. This could mean that most consumers liked these characteristics in craft beers. It is important to mention that the characteristics: presence of exotic fruit, fruit aroma, presence of Andean cereals, and high content of alcohol were attractive characteristics of the Kano model for the consumer of beers in Lima, which could explain the high percentage of consumers who like them.

IRA and BBA samples were characterized mainly by their aroma (EBC), and LA by its high pH. They were also characterized in a sensorial way due to their malted taste, earthy aroma, red color, and dark brown color. This could mean that these characteristics are liked by a percentage between 70 and 60 % of consumers of craft beers from the city of Lima. (Guinard et al., 2001) in their comparative study of characteristics of lager beers, using internal and external preference mapping, determined that characteristics such as malted taste, dry hop, and low carbonation are characteristics of a high-quality ale beer mostly preferred by consumers. Considering individual punctuations, two zones of the sensorial space are seen at the extremes, which revealed more predilection by consumers. Thus, it would result convenient to develop craft beers with sensorial characteristics like the ones of these four samples.

4. Conclusions

The Kano model defined that the attractive characteristics of Peruvian craft beers for consumers in the city of Lima (socio-economic sectors B and C), were the presence of exotic fruits, fruit aroma, presence of Andean cereals, and high content of alcohol. The analysis of the main components (PCA) provided physicochemical characterizations of the six samples of Peruvian craft beer and, a hierarchical conglomerate analysis grouped them according to their similarities. It was also determined that craft IPA and APA beers belonged to the same group and were characterized by their bitterness; IRA and BBA beers were grouped by their dark color, and LA and FBGSA were mainly grouped by their high grade of alcohol. The *Napping®-Ultra Flash Profile* methodology characterized all the samples of Peruvian craft beer in a sensorial way and were also gathered through a *Bootstrap Total Trunk* method. The IPA and APA samples were grouped and characterized for the presence of lots of beer foam, for being astringent, bitter, and due to its extended

residual bitterness. Samples of LA and FBGSA beer were mostly grouped and characterized for flower aroma, herbal aroma, fruit aroma, a golden color, burbling, exotic fruit, high content of alcohol, and Andean cereals. BBA and IRA beers were characterized for showing malted taste, dark brown color, earthy smell, and red color. The External Preference Mapping revealed that samples of APA and IPA craft beer were placed in an area where the percentage of consumers that liked them was 30 and 40 %. The samples most preferred by customers were FBGSA, LA, BBA, and IRA, which were situated near zones where the percentage of consumers who high graded general taste was 80, 70, 70, and 60 %, respectively. The results demonstrated that the integration of the studied methods can be a powerful tool in the development of new food and beverage products, providing a safe and objective guide to the most relevant sensory characteristics of the product, which could be used for mathematical modeling such as Kansei engineering, conjoint analysis, among others.

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References

Antúnez, L., Vidal, L., De Saldamando, L., Giménez, A., & Ares, G. (2017). Comparison of consumer-based methodologies for sensory characterization: Case study with four sample sets of powdered drinks. *Food Quality and Preference*, *56*, 149–163. doi:10.1016/j.foodqual.2016.09.013

AOAC. (2016). *Official Methods of Analysis of Association of AOAC International*. (G. W. Latimer, Ed.) (20th ed.). Maryland.

Aquilani, B., Laureti, T., Poponi, S., & Secondi, L. (2015). Beer choice and consumption determinants when craft beers are tasted: An exploratory study of consumer preferences. *Food Quality and Preference*, *41*, 214–224. doi:10.1016/j.foodqual.2014.12.005

Ares, G., Antúnez, L., Bruzzone, F., Vidal, L., Giménez, A., Pineau, B., ... Jaeger, S. R. (2015). Comparison of sensory product profiles generated by trained assessors and consumers using CATA questions: Four case studies with complex and or similar samples. *Food Quality and Preference*, *45*, 75–86. doi:10.1016/j.foodqual.2015.05.007

Barth-Haas Group. (2021). World beer production. Statista. https://www.statista.com/statistics/270275/worldwide-beer-production/.

Blackmore, H., Hidrio, C., & Yeomans, M. R. (2022). How sensory and hedonic expectations shape perceived properties of regular and non-alcoholic beer. Food Quality and Preference, 99, 104562.

Bruzzone, F. (2014). *Aplicación de metodologías de caracterización sensorial con consumidores en el desarrollo de postres lácteos funcionales*. Universidad de la República Aplicación.

Cadoret, M., & Husson, F. (2013). Construction and evaluation of confidence ellipses applied at sensory data. *Food Quality and Preference*, *28*(1), 106–115. doi:10.1016/j.foodqual.2012.09.005

Carvalho, D. O., Øgendal, L. H., Andersen, M. L., & Guido, L. F. (2016). High molecular weight compounds generated by

roasting barley malt are pro-oxidants in metal-catalyzed oxidations. *European Food Research and Technology*, *242*(9), 1545–1553. doi:10.1007/s00217-016-2655-7

Chen, Y. H., & Su, C. T. (2006). A Kano-CKM model for customer knowledge discovery. *Total Quality Management and Business Excellence*, *17*(5), 589–608. doi:10.1080/14783360600588158

Chollet, S., Lelièvre, M., Abdi, H., & Valentin, D. (2011). Sort and beer: Everything you wanted to know about the sorting task but did not dare to ask. *Food Quality and Preference*, *22*, 507–520. doi:10.1016/j.foodqual.2011.02.004

Coghe, S., Gheeraert, B., Michiels, A., & Delvaux, F. R. (2006). Development of maillard reaction related characteristics during malt roasting. *Journal of the Institute of Brewing*, *112*(2), 148–156. doi:10.1002/j.2050-0416.2006.tb00244.x

De Azevêdo, J. C. S., Fujita, A., de Oliveira, E. L., Genovese, M. I., & Correia, R. T. P. (2014). Dried camu-camu (Myrciaria dubia H.B.K. McVaugh) industrial residue: A bioactive-rich Amazonian powder with functional attributes. *Food Research International*, *62*, 934–940. doi:10.1016/j.foodres.2014.05.018

Dehlholm, C., Brockhoff, P. B., Meinert, L., Aaslyng, M. D., & Bredie, W. L. P. (2012). Rapid descriptive sensory methods - Comparison of Free Multiple Sorting, Partial Napping, Napping, Flash Profiling and conventional profiling. *Food Quality and Preference*, *26*, 267–277. doi:10.1016/j.foodqual.2012.02.012

Delarue, J., Lawlor, J. Ben, & Rogeaux, M. (2015). *Rapid Sensory Profiling Techniques and Related Methods*. Cambridge: Woodhead Publishing.

Escofier, B., & Pagès, J. (1998). Analyses factorielles simples et multiples. Dunod, Paris, 284.

Euromonitor International. (2019). Beer in Perú. Retrieved from https://www.euromonitor.com/beer-in-peru/report

Ferreira, I. M. P. L. V. O., Jorge, K., Nogueira, L. C., Silva, F., & Trugo, L. C. (2005). Effects of the combination of hydrophobic polypeptides, iso-α acids, and malto-oligosaccharides on beer foam stability. *Journal of Agricultural and Food Chemistry*, *53*(12), 4976–4981. https://doi.org/10.1021/jf047796w

Giacalone, D. (2013). *Consumers' perception of novel beers: sensory, affctive, and cognitive-contextual aspects*. University of Copenhagen.

Giacalone, D., Ribeiro, L. M., & Frøst, M. B. (2013). Consumer-Based Product Profiling: Application of Partial Napping® for Sensory Characterization of Specialty Beers by Novices and Experts. *Journal of Food Products Marketing*, *19*(3), 201–218. doi:10.1080/10454446.2013.797946

Guinard, J. X., Uotani, B., & Schlich, P. (2001). Internal and external mapping of preferences for commercial lager beers: Comparison of hedonic ratings by consumers blind versus with knowledge of brand and price. *Food Quality and Preference*, *12*, 243–255. doi:10.1016/S0950-3293(01)00011-8

Hahn, C. D., Lafontaine, S. R., Pereira, C. B., & Shellhammer, T. H. (2018). Evaluation of Nonvolatile Chemistry Affecting Sensory Bitterness Intensity of Highly Hopped Beers. *Journal of Agricultural and Food Chemistry*, *66*(13), 3505–3513. doi:10.1021/acs.jafc.7b05784

INACAL (Instituto Nacional de calidad). (2015). Cerveza. Alcohol en cerveza por destilación. Lima, Perú.

INACAL (Instituto Nacional de calidad). (2016a). Cerveza. Determinación de pH en cerveza. Lima, Perú.

INACAL (Instituto Nacional de calidad). (2016b). Cerveza. Método de referencia para la determinación de amargor en cervezas. Lima, Perú.

INACAL (Instituto Nacional de calidad). (2016c). Cerveza. Método espectrofotométrico para la determinación del color. Lima, Perú.

Kano, N., Seraku, N., Takahashi, F., & Tshuji, S. (1984). Attractive quality and must-be quality. *Journal of Japanese Society for Quality Control*, *41*(2), 165–186.

Kemp, S. E., Hort, J., & Hollowood, T. (2018). *Descriptive analysis in sensory evaluation*. New York: John Wiley & Sons, Inc.

Kobayashi, M.; Benassi, M. 2012. Caracterização sensorial de cafés solúveis comerciais por Perfil Flash. Semina: Ciências Agrárias. 33(2):3081-3092.

Lawless, H., & Heymann, H. (2010). *Sensory Evaluation of Food* (2nd ed.). New York: Springer.

Lehnhardt, F., Steiner, J., Gastl, M., & Becker, T. (2018). Prediction power and accuracy of forced ageing – Matching sensory and analytical results for lager beer. *BrewingScience*, *71*, 39–48. doi:10.23763/BrSc18-05lenhardt

Le, M. T. (2015). Réflexions méthodologiques autour du Napping : vers une intégration du comportement du sujet dans l' analyse des données de Napping. Retrieved from https://tel.archives-ouvertes.fr/tel-01534044

Le, S., & Husson, F. (2008). SENSOMINER : A Package for sensory data analysis. *Journal of Food Science*, *23*(1), 14–25. doi:https://doi.org/10.1111/j.1745-459X.2007.00137.x

Liñan-Pérez, J. F. (2019). Aplicación de los métodos kano y cata para el desarrollo de brownie libre de gluten.

Llinares, C., & Page, A. F. (2011). Kano's model in Kansei Engineering to evaluate subjective real estate consumer preferences. *International Journal of Industrial Ergonomics*, *41*(3), 233–246. doi:10.1016/j.ergon.2011.01.011

Louw, L., Malherbe, S., Naes, T., Lambrechts, M., van Rensburg, P., & Nieuwoudt, H. (2013). Validation of two Napping® techniques as rapid sensory screening tools for high alcohol products. *Food Quality and Preference*, *30*(2), 192–201. doi:10.1016/j.foodqual.2013.05.016

Machado, J. C., Martins, Z. E., & Ferreira, I. M. (2023). Dynamic sensory analysis by Temporal Dominance of Sensations paired with dynamic liking and wanting methodologies to understand the consumers' preference between two beer styles enriched with elderberries. LWT, 173, 114266.

Maeda, R. N., & Andrade, J. S. (2003). Aproveitamento do camu-camu (Myrciaria dubia) para produção de bebida alcoólica fermentada. *Acta Amazonica*, *33*(3), 489–498. doi:10.1590/s0044-59672003000300014

Malowicki, M. G., & Shellhammer, T. H. (2005). Isomerization and degradation kinetics of hop (Humulus lupulus) acids in a model wort-boiling system. *Journal of Agricultural and Food Chemistry*, *53*(11), 4434–4439. doi:10.1021/jf0481296

Martínez, A., Vegara, S., Herranz-López, M., Martí, N., Valero, M., Micol, V., & Saura, D. (2017). Kinetic changes of polyphenols, anthocyanins and antioxidant capacity in forced aged hibiscus ale beer. *Journal of the Institute of Brewing*, *123*(1), 58–65. doi:10.1002/jib.387

Matzler, K., Bailom, F., Sauerwein, E., & Hinterhuber, H. H. (1996). How to delight your customers. *Journal of Product & Brand Management*, *5*(2), 6–18. doi:10.1108/10610429610119469

Maye, J. P., Smith, R., & Leker, J. (2016). Master Brewers Association of the Americas, Humulinone Formation in Hops and Hop Pellets and Its Implications for Dry Hopped Beers. *Master Brewer Association of America*, *53*(1), 23–27.

Mayhew, E., Schmidt, S., & Lee, S. Y. (2016). Napping-Ultra Flash Profile as a Tool for Category Identification and Subsequent Model System Formulation of Caramel Corn Products. *Journal of Food Science*, *00*(0), 51–59. doi:10.1111/1750-3841.13338

Meilgaard, M. C., Dalgliesh, C. E., & Clapperton, J. F. (1979). Beer Flavour Terminology. *Journal of the Institute of Brewing*, *85*(1), 38–42. doi:10.1002/j.2050-0416.1979.tb06826.x

Meilgaard, Morten C, Civille, G. V., & Carr, B. T. (2016). *Sensory Evaluation Techniques* (5th ed.). Boca Raton: CRC Press, Taylor & Francis Group.

Meneses, J. E. (2017). *Optimización de los parámetros de osmodeshidratación y secado por convección para la retención de carotenos del zapallo loche (Cucúrbita moschata Dutch.)*. Universidad Señor de Sipán.

Mora, M., Giussani, B., Pagliarini, E., & Chaya, C. (2019). Improvement of an emotional lexicon for the evaluation of

beers. *Food Quality and Preference*, *71*, 158–162. doi:10.1016/j.foodqual.2018.06.007

Nijman, M., James, S., Dehrmann, F., Smart, K., Ford, R., & Hort, J. (2019). The effect of consumption context on consumer hedonics, emotional response and beer choice. *Food Quality and Preference*, *74*, 59–71. doi:10.1016/j.foodqual.2019.01.011

Oliver, P., Cicerale, S., Pang, E., & Keast, R. (2018). Comparison of Quantitative Descriptive Analysis to the Napping methodology with and without product training. *Journal of Sensory Studies*, *33*(3), 1–11. doi:10.1111/joss.12331

O'Sullivan, M. (2017). *A Handbook for Sensory and Consumer-Driven New Product Development*. Cambridge: Woodhead Publishing.

Pagès, J. (2003). Recueil direct de distances sensorielles: application à l'évaluation de dix vins blancs du Val-de-Loire. *Sciences Des Aliments*, *23*, 679–688. doi:10.3166/sda.23.679-688

Pagès, J. (2005). Collection and analysis of perceived product inter-distances using multiple factor analysis: Application to the study of 10 white wines from the Loire Valley. *Food Quality and Preference*, *16*, 642–649. doi:10.1016/j.foodqual.2005.01.006

Perrin, L., & Pagès, J. (2009). Construction of a product space from the ultra-flash profiling method: Application to 10 red wines from the loire valley. *Journal of Sensory Studies*, *24*(3), 372–395. doi:10.1111/j.1745-459X.2009.00216.x

Perrin, L., Symoneaux, R., Maître, I., Asselin, C., Jourjon, F., & Pagès, J. (2008). Comparison of three sensory methods for use with

the Napping® procedure: Case of ten wines from Loire valley. *Food Quality and Preference*, *19*, 1–11. doi:10.1016/j.foodqual.2007.06.005

Prado, R., Gastl, M., & Becker, T. (2023). Influence of kilned specialty malt odorant markers on the aroma composition and sensory profile of beer. LWT, 173, 114195.

Puma-Isuiza, G. G., & Núñez-Saavedra, C. (2018). Desarrollo de hot-dog a base de carne de pollo (Gallus gallus) mediante la Ingeniería Kansei Tipo II. *Anales Científicos*, *79*(1), 201–209. doi:http://dx.doi.org/10.21704/ac.v79i1.1164

Santos, B. A., Pollonio, M. A. R., Cruz, A. G., Messias, V. C., Monteiro, R. A., Oliveira, T. L. C., ... Bolini, H. M. A. (2013). Ultra-flash profile and projective mapping for describing sensory attributes of prebiotic mortadellas. *Food Research International*, *54*, 1705–1711. doi:10.1016/j.foodres.2013.09.022

Sauerwein, E., Bailom, F., Matzler, K., & Hinterhuber, H. H. (1996). *The Kano model: How to delight your customers*. In *IX. International Working Seminar on Production Economics* (Vol. I, pp. 313–327). Innsbruck.

Simpson, W. J. (2016). Sensory Analysis in the Brewery. In C. W. Bamforth (Ed.), *Brewing Materials and Processes: A Practical Approach to Beer Excellence* (pp. 257–289). California: Academic Press. doi:10.1016/B978-0-12-799954-8.00013-7

Varela, P., & Ares, G. (2014). *Novel Techniques in Sensory Characterization and Consumer Profiling*. Boca Raton: CRC Press. doi:https://doi.org/10.1201/b16853