UNIVERSIDAD AUTÓNOMA METROPOLITANA

Unidad Iztapalapa

Casa abierta al tiempo

División de Ciencias Biológicas y de la Salud

Departamento de Biotecnología

FOOD AND BEVERAGE PAIRING FROM A SENSORY AND CULTURAL PERSPECTIVE

MARIDAJE DE ALIMENTOS Y BEBIDAS DESDE UNA PERSPECTIVA SENSORIAL Y CULTURAL

T E S I S

DOCTORADO EN BIOTECNOLOGÍA

ARACELI ARELLANO COVARRUBIAS

Director: Dr. Héctor Bernardo Escalona Buendía (UAM-I)

Co-directora: Dra. Paula Varela Tomasco (NOFIMA)

Asesor: Dr. Carlos Gómez Corona (FIRMENICH SA)

MÉXICO **2021**

El Doctorado en Biotecnología de la Universidad Autónoma Metropolitana está incluido en el Programa Nacional de Posgrados de Calidad (PNPC) del Consejo Nacional de Ciencia y Tecnología (CONACyT), con la referencia 001466

Esta tesis se llevó a cabo en el Laboratorio de Análisis Sensorial y de Estudios con Consumidor del Departamento en Biotecnología de la Universidad Autónoma Metropolitana, Unidad Iztapalapa.

La tesis fue financiada con la beca número 520074/574751 otorgada por el CONACYT a Araceli Arellano Covarrubias.

Ciudad de México, a 18 de noviembre del 2021

El Honorable Jurado designado por la División de Ciencias Biológicas y de la Salud de la Universidad Autónoma Metropolitana unidad Iztapalapa **aprobó** la tesis.

FOOD AND BEVERAGE PAIRING FROM A SENSORY AND CULTURAL PERSPECTIVE

MARIDAJE DE ALIMENTOS Y BEBIDAS DESDE UNA PERSPECTIVA SENSORIAL Y CULTURAL

Que presentó Araceli Arellano Covarrubias

Con el comité tutorial:

Dr. Héctor Bernardo Escalona Buendía

Director, UAM –Iztapalapa

Dra. Paula Varela Tomasco

Co-Directora, NOFIMA

Dr. Carlos Gómez Corona

Asesor, Firmenich SA

Dr. Gastón Ares Devincenzi	Universidad de la República, Uruguay	
Dr. Carlos Gómez Corona	Firmenich SA, Francia	
Dra. Leticia Vidal Berriel	Universidad de la República, Uruguay	
Dra. María Amparo Tárrega Guillem	IATA, España	

ACKNOWLEDGMENTS/AGRADECIMIENTOS

A las personas que han estado a mi lado en todos los pasos de mi vida.

A mis padres, **Gloria** y **Arturo**, por todo el apoyo que me han brindado en cada una de mis decisiones, por sus grandes enseñanzas, por guiarme y siempre encontrar las palabras perfectas para motivarme a tratar de ser una mejor persona cada día. Gracias, por todos los detalles, por todo el amor que me demuestran con pequeñas y grandes acciones. Gracias por estar presentes siempre.

A mis hermanos, **Mitzi** y **Arturo**. Gracias por hacer más divertida mi vida, por su ayuda en diversas situaciones, por sus consejos, por su compañía. Porque a pesar de los buenos y malos momentos, siempre he podido contar con ustedes. Gracias por todo lo que han hecho y siguen haciendo por mí.

Finalmente, gracias, **Miguel**. Por llegar a mi vida, por estar a mi lado en esta gran etapa, y porque también es gracias a ti que todo esto ha sido posible. Gracias por cada momento de ayuda y de consuelo en momentos complicados. Gracias por tus palabras de aliento, por las risas, por hacer más llevaderas las situaciones difíciles y, sobre todo, gracias por seguir caminando de mi mano.

Este proyecto es principalmente gracias a ustedes.

Al **Dr. Héctor,** por su guía, por la dirección de este trabajo y por todas las enseñanzas personales y académicas que me brindó a lo largo del mismo.

A **Paula**, porque a pesar de la distancia, siempre tuvo momentos para brindarme su ayuda. Gracias por todas las sugerencias y apoyo para mejorar este proyecto.

A **Carlos**, gracias por tus consejos, sugerencias, por haber tenido tu apoyo desde el comienzo de este proyecto y por estar siempre al pendiente en cada uno de los pasos del mismo.

Finalmente, gracias a mis compañeros de laboratorio, amigos, los cuales hicieron mucho más divertida esta etapa.

SUMMARY

This thesis focuses on the study of food and beverage pairing perception, with the objective of increasing our understanding of the cultural and sensory phenomena underlying the act of pairing. Over the last few years, food pairing has received increasing attention among scientists, chefs, and gastronomists who want to find successful food combinations and identify a pattern of how consumers pair certain foods. In consequence, food and beverage pairing has been studied by diverse disciplines like gastronomy, sensory science, consumer research, and history. Most of the available research has stated that, besides the intrinsic characteristics of products, such as their chemical and physical properties, several factors influence the way consumers pair food, with culture being a key factor. Despite the popularity of food pairing, there is still a lack of agreement about which methods are more appropriate for its research in sensory and consumer science fields. Therefore, the main scope of this thesis is the use of non-traditional and innovative methods that enable the study of food and beverage pairing through the eyes of consumers in different cultures. Social media investigation and projective mapping with consumers were explored as alternatives to traditional methods. In addition, the influence of culture on the perception of food and beverage pairing was investigated. Results showed that social media could be a suitable methodology to research the relationship between foods and beer pairing across countries. In particular, image-based platforms could provide detailed information regarding food-beverage pairing and its context of consumption. In the case of projective mapping, the method proved to be a valuable tool for exploring consumers' food-beverage pairing and made it easy to understand the similarities and differences across participants from different cultures. To sum up, the results of this thesis showed that non-traditional methodologies could be used to better understand consumers perception regarding food and beverage pairings, as well as to explore the influence of culture.

RESUMEN

Esta tesis se enfoca en el estudio de las percepciones del maridaje de alimentos y bebidas con el objetivo de incrementar nuestro entendimiento de los fenómenos culturales y sensoriales que subyacen al acto de maridar. Durante los últimos años, el maridaje de alimentos ha recibido gran atención entre científicos, chefs y gastrónomos que intentan encontrar combinaciones exitosas e identificar un patrón de cómo los consumidores combinan los alimentos. En consecuencia, el maridaje de alimentos y bebidas ha sido estudiado en diversas disciplinas, como gastronomía, ciencia sensorial, ciencia del consumidor e historia. La mayor parte de la literatura disponible indica que además de las características intrínsecas de los productos alimenticios (como la química y física de los alimentos), otros factores influyen en la forma en la que los consumidores combinan los alimentos, siendo la cultura uno de esos factores. A pesar de la popularidad del maridaje de alimentos, existe una falta de metodologías adecuadas para su investigación en los campos de la ciencia sensorial y del consumidor. Por lo tanto, el principal alcance de esta tesis es el uso de métodos no tradicionales e innovadores que permitan el estudio del maridaje de alimentos y bebidas a través de los ojos de los consumidores en diferentes culturas. En específico, las redes sociales y el mapeo proyectivo fueron explorados como alternativas a los métodos tradicionales. Los resultados mostraron que las redes sociales pueden ser una metodología adecuada para estudiar la relación entre alimentos y bebidas en diferentes países. Se debe prestar atención especial a las plataformas basadas en imágenes, las cuales podrían proporcionar información más detallada sobre el maridaje de alimentos y bebidas. Por otro lado, el mapeo proyectivo proporcionó evidencia de ser una herramienta valiosa al analizar las distancias entre productos y, por lo tanto, explorar la forma en que los consumidores maridan alimentos y bebidas. Asimismo, el mapeo proyectivo permitió explorar las similitudes y diferencias entre los participantes de diferentes culturas. En general, los resultados de esta tesis mostraron que las metodologías no tradicionales pueden ser utilizadas para comprender las combinaciones de alimentos y bebidas, así como explorar la influencia de la cultura en las percepciones de los consumidores hacia el maridaje de alimentos y bebidas.

INDEX

Introduction

Food pairing can be considered as the creative side of cooking (Klepper, 2011). It can occur when two foods or food and beverages that are consumed together produce a better sensory experience than when each one is consumed alone (Lahne, 2018). In recent years, scientists from different disciplines have become more and more interested in trying to understand the principles underlying the successful pairing of foods. Analogously, chefs and gastronomists are in constant search of new and successful recipes of food combinations.

If we look further than food combinations, beverages are also important as a main part of the total eating event (Scander, 2019) and combination. Since humans do not usually consume food alone but mainly accompanied with some beverage, this fact reveals the need to research the whole sensory experience of food and beverage combinations (Galmarini, 2020). Over the centuries, chefs and sommeliers have combined and recommended the “ideal food and beverage combinations” (Paulsen et al., 2015) in different cultures, based on their experience and tacit knowledge (Herdenstam et al., 2009). However, some of these combinations can be applied only to specific cultures (where the initial pairing was done) and can not necessarily be extended to other cultures.

Why may the pairing only apply to specific cultures? If we follow the ideas expressed by Rozin (2002, 1996), in which cultures have developed elaborate ways of selecting and preparing foods, these foods are a social entity considered an integral part of a region’s cultural heritage (Makinei et al., 2021), and so are their pairings. In other words, it is not just the food that has social entity, but also the way it is prepared, mixed, and combined with other foods and beverages.

Despite the importance that food and beverage pairing has for the different fields previously mentioned (e. g., Gastronomy, Sensory Science, Consumer Research, etc.), the study of food and beverage pairing is still in its early stages, and the dynamics of the pairings are not entirely understood. Most of the publications so far have focused on wine and food pairing (Harrington et al., 2010) or different products with only a small set of elements, such as banana with basmati rice, bacon, and extra virgin olive oil (Traynor et al., 2013), chocolate and beverage pairing (Donadini et al., 2012), virgin olive oil and shrimps (Cerretani et al., 2007), and cheese and beer pairings (Donadini, Fumi, & Lambri, 2013). In this context, this thesis aims to explore different approaches in consumer research that could allow us to better understand consumer perception of food and beverage pairing and its differences across different cultures. Alcoholic beverages and in particular beer, will be the case study due to their economic and cultural relevance in different countries.

Literature review

1. Food pairing

In the recent years, the search for successful food combinations has been in the minds of many chefs (Klepper, 2011), scientists and gastronomists. Nevertheless, a clear definition of food pairing has not been precisely proposed (Rune et al., 2021). On the one hand, the popular literature (e.g., newspaper, magazines, websites) defines food pairing as the practice of identifying food combinations that taste good together. On the other hand, the scientific literature defines food pairing as foods or food and a beverage that, when consumed together, may present different sensory properties than when consumed alone (Lahne, 2018).

In this sense, the sensory properties of foods play a core role in how consumers perceive them. Some sensory characteristics include appearance (color, size, shape), texture, temperature, sound, and flavor (Jain & Gupta, 2005). The last one includes odors (due to molecules that could bind to the olfactive receptors), tastes (due to molecules that stimulate the taste buds), and freshness or pungency (trigeminal sensations) (Ahn et al., 2011). The release of the flavor compounds is an essential prerequisite for the perception of food and one of the most important parameters in sensory perception (Samavati et al., 2012), as well as consumer acceptance (Liu & Yang, 2002). Therefore, the chemical components of the ingredients in a recipe seem to be a natural starting point for searching for principles that might underlie consumers' choice of acceptable food combinations (Ahn et al., 2011).

Based on the above, and due to the great interest surrounding finding successful food pairings, different theories of food pairing have been proposed. The most popular theory is known as "food pairing theory", which is based on flavor perception across the paired products. It was designed to create new food combinations, determining the compatibility between ingredients at a molecular level (aromatic compounds of a food). The theory is based on the fact that our nose picks up 80% of the volatile compounds in foods, while 20% of the food's flavor is determined by mouthfeel and taste. Therefore, the central hypothesis of food pairing theory states that the more aromatic compounds two foods have in common, the better they taste together (Klepper, 2011).

The food pairing hypothesis has become popular over the last decade and has been used to search for new ingredient combinations, such as white chocolate and caviar, as they share trimethylamine as their common aromatic compound. Another example is chocolate and blue cheese, which share at least 73 flavor compounds, according to Ahn et al. (2011). Another successful combination that was found using this approach of shared aromatic compounds, is pork liver with jasmine, which share indole as the volatile compound (Klepper, 2011).

In general, the food pairing theory has been helpful in identifying new food combinations; however, although the food pairing theory remains popular, some criticism has also arisen. For example, the fact that a one-to-one mapping between the molecular structure and the associated flavor experience does not exist (Spence, 2020). Klepper (2011) also criticized the main hypothesis of this theory, which states that the more aromatic compounds two foods have in common, the better they taste together. Nevertheless, some contradictions have been found. For instance, Kort et al. (2007) tested the hypothesis with naive participants (with no gastronomy or specific technical training) and reported their results in a conference proceeding paper. Klepper (2011) referred to these results as “food pairings with more aroma overlap did not taste better than food pairings with less overlap”. One of the case studies, chocolate and tomato (with 43% overlap), did not taste better than cauliflower and pear (no apparent overlap).” Finally, the food pairing theory assumes that all successful food combinations are based on their natural composition. However, the literature shows that food preferences and successful food combinations are learned or culturally influenced. An example used by Klepper (2011) was cinnamon and tomato pairing which, according to the “sharing” theory, would not be a good match. However, it is one of the characteristic flavor combinations of traditional Greek food. Consequently, the use of the food pairing hypothesis neither guarantees nor necessarily predicts good food-beverage combinations (Spence, 2020).

In the same line as the food pairing hypothesis, the “food-bridging hypothesis” has also been raised, which assumes that if two ingredients that do not share volatile compounds (and therefore, do not taste good) may taste good if there exists a third ingredient with shared volatile compounds between the initially proposed foods. For example, if apricot and whiskey gum do not share volatile compounds but they are joined (or bridged) with tomato, they will taste good if tomato shares volatile compounds with apricot and whiskey gum (Simas, 2017). Food pairing and food-bridging intend to describe possible mechanisms behind the recipes of traditional cuisines, the former being the most popular that has been tested. However, researchers have reached controversial results. A factor to consider in sensory consumer research is that an accepted food among consumers might contain hundreds of volatile compounds, and their interactions are commonly complex. For example, a mixture of two chemicals usually smells weaker than the sum of its parts Wright (2010).

It is important to highlight that past theories focus on aromatic compounds shared, and therefore, other product attributes are not taken into consideration, especially the non-volatile compounds (e.g., fat types and basic tastes) (Herrera, 2021). In addition to the non-volatile compounds, Spence et al. (2017) have also highlighted that not all ingredients are incorporated into a recipe solely for the flavor they impart, but sometimes they might be added to enhance the color or change the final product’s texture. Moreover, these food pairing theories have been developed with the use of ingredients in a recipe, but not to complete foods or meals, and much less in the combination of food and beverages.

1.1 Food and beverage pairing

Beverages are as important as food in understanding eating patterns (Scander, 2019). Therefore, the need to study the complete experience of eating the food and drinking specific beverages is of great relevance in the sensory and gastronomic field (Galmarini, 2020). Foods are not consumed alone, and some of the most common beverages are beer and wine, at least in the alcoholic beverages category. Understanding them can shed light on the pairing of other beverages.

In the case of wine, some cultures have established specific rules and habits of their combination with food and specific food preparations. The case of France can be of specific relevance and interest, and while extensive literature states some pairing recommendations, identifying a general strategy to create a good match is still difficult (Eschevins, 2019). Food and beverage alcohol pairings enhance the dining experience. While wine has been traditionally associated with food pairings (Martínez et al., 2017), Donadini et al. (2008) found that regular consumers do not randomly pair beer with food either.

In the scientific literature, most of the wine and food pairing research arises from the evaluation of consumer hedonic responses to the combined elements. These studies provide evidence of cheese as a good wine pair, and there are conflicting results on diverse wine styles associated with different cheeses. For example, Bastian et al. (2010) evaluated the liking of Australian Shiraz wines and Cheddar cheese pairs, and found that all the pairings were liked by the consumers. In another study, Bastian et al. (2009) paired eight different cheeses with eight different style wines, and the authors found that, in general, the pairs were considered ideal by the consumers. However, some exceptions were found. Consumers proposed pairing Sauvignon blanc with Gruyère instead of goat's cheese, and Chardonnay wine with Gruyère or Chaource instead of Brie de Maux.

In recent years, other beverages, besides wine, and foods have become the object of pairing studies (Lahne, 2018). For example, tea (Donadini & Fumi, 2014), chocolate (Donadini et al. 2012; Paz, et al., 2021), cheese (Donadini, et al., 2013; Bastian et al., 2010), virgin olive oil (Cerretani et al., 2007; Cichelli et al., 2020), and specifically in the alcoholic beverage domain, there are some food pairing studies with beverages like sake (Fujita et al., 2010). However, little is known about beer pairing and only some articles have been published. (Pettigrew & Charters, 2006; Eschevins et al., 2019; Martínez et al., 2017; Donadini et al., 2008; Paulsen et al., 2015; Donadini et al., 2013).

It has been conventionally stated that some beer and dish pairings are better than others. For instance, Donadini et al. (2008) found that certain flavors of food and beers combine better together than others. Additionally, Pettigrew and Charles (2006) found that the location, such as eating place or where consumers live, could also impact the way they choose to combine their food and beverages. In this sense, food and beverage pairing could be culturally influenced. Understanding how consumers from different cultures pair food and beverages could be the key to the success of food and beverage combinations.

2. Culture

Cultural background, tradition, and eating habits should be considered when exploring food and beverage pairing. For instance, two flavors that would work in one culture may not be relevant in another (Eschevins et al.,2019). Previously, the ideas around food culture from Rozin (2002, 1996) that were developed in the introduction, and recent publications like Ahn, et al. (2011) or Jeong and Lee (2021), also mentioned that cultural diversity of culinary practice raises the question of whether any principles determine the ingredient combinations used in food today. In this sense, a common way of finding successful food pairings amongst consumers is by exploring ethnic, regional, and national cuisines to discover their characteristic flavor principles (Keppler, 2011). For example, the Mexican and French cultures, as well as other cultures, are full of meanings and symbols associated with the act of drinking and eating. Mexicans learn to eat chili and develop a preference for it since they are children (Rozin & Schiller, 1980), transforming an intense pungency into a pleasant sensation. French people learn to drink and appreciate wine when they are young, and how to combine red wine with certain foods and white wine with others. In this way, eating chili and drinking wine can be considered as cultural identifiers.

The available literature addressing the cultural aspects of food pairing is limited. Kim et al. (2018) evaluated the acceptance levels and drivers of liking and disliking hot sauces among consumers from three countries (South Korea, the US, and Denmark). In this study, participants evaluated the hot sauces applied to four food items (pizza, cream soup, grilled chicken wings, rice noodle soup). The authors found that the pairing of particular sauces with specific food items is culture dependent.

Some other authors have explored the influence of culture by assessing the food pairing theory. Ahn et al. (2011) found that, in general, both Western and European cuisine use ingredients that share similar flavor compounds, while East Asian cuisine does the opposite. Following this last statement, Jain and Bagler (2015) found that different regional Indian cuisines did not follow the food pairing hypothesis. In their study, the authors found that the higher the flavor sharing between two ingredients of Indian recipes, the lower co-occurrence in that cuisine. Similar results were found by Makinei et al. (2021) when evaluating the food pairing patterns of the Assamese cuisine of Northeast India.

Using the same dataset as Ahn et al. (2011), Simas et al. (2017) explored the influence of culture by introducing the food bridging theory and comparing it to the food pairing theory. The authors found that East Asian cuisines tend to avoid both food pairing and food bridging, while Latin American cuisines follow both principles. In the case of Southeastern Asian cuisines, they avoid food pairing but follow food bridging; contrarily to Western cuisines which follow food pairing and avoid food bridging.

3. Methodologies applied in the research of food pairing

Several approaches have been applied to find ideal food pairings, to assess how consumers pair food, or how some foods could influence the perception of the pairing. Hedonic tests have been widely used when exploring consumers' responses to cheese and beer pairings (Donadini et al., 2013) or wine and food combinations (Harrington & Seo, 2015). Bastian et al. (2010) also evaluate the pairings of wine and cheese by using hedonic tests and an adaptation of the Just Right Scale (JAR) used previously by King and Cliff (2005). Consumers were instructed to place a vertical line on the JAR scale rating whether the wine (right of the scale) or the cheese (left of the scale) dominated the pair, or to place it in the middle of the scale if the combination was an "ideal match".

Eschevins et al. (2018) manipulated the aromatic similarity by aromatizing drinks (lemon soft drink and beer) and food. The authors used rating scales to evaluate liking, harmony, homogeneity, complexity, balance, and familiarity of the pairings. Other authors evaluated the impact of wine on the perception of cheese (Galmarini et al., 2017), where the cheeses were dynamically characterized by using Temporal Dominance of Sensations (TDS) coupled with a hedonic rating.

Ahn et al. (2011) introduced a network-based approach by building a bipartite network of chemical flavor compounds and food ingredients from many recipes (56,498) of different cuisines. The bipartite network consisted of two types of nodes. The first one included the ingredients used in recipes, and the second one included the compounds that contribute to the flavor of each ingredient. In this way, the authors built a flavor-network in which two nodes/ingredients were connected if they shared at least one flavor compound. Similarly, Varshney et al. (2013) collected a data set of recipes from Medieval Europe before the Columbian exchange, and studied the flavor pairing hypothesis historically by following the computational statistic method of Ahn et al. (2011).

Some aspects should be considered when performing the methodologies surrounding food and beverage pairing. For instance, several studies intend to find an "ideal pairing" by applying the JAR adaptation of testing whether a food or beverage dominates a pair (Bastian et al., 2010; Donadini et al., 2012; Donadini et al., 2013). However, the controversy of this approach arises from the assumption that in an "ideal pair" neither the food nor the beverage' taste is more dominant (Lahne, 2018). In fact, Donadini et al. (2013) found that consumers preferred beer and cheese pairings when the cheese was dominant and disliked the "ideal pairings".

Harrington and Hammond (2005) studied the level of perceived cheese and wine match by using a 9-point scale (1= No match, 5= average match, and 9= synergistic match). The authors defined a non- match when the wine and cheese pair produced a negative impact on the senses, and a synergistic match when a pair produced an ideal gastronomic effect. From this approach, some aspects should be considered. The research was performed by using a trained panelist and despite the fact that no hedonic rating was applied, their hedonic perceptions for a negative or positive impact on the senses was evaluated.

In general, research involving consumers is needed in the food and beverage pairing field. However, most of the consumer research requires that consumers think about their behavior, which could lead to misleading responses. What is more, consumers may answer questions with socially desirable answers (Köster, 2003), which could also compromise the validity of the data. In addition, while the above-mentioned approaches have produced results, there is still the need to test food and beverage pairing in real situations (Lahne, 2018). This last statement is reinforced by the literature showing that consumer liking and consumption behavior has been found to be different outside the laboratory than within it (Petit & Sieffermann, 2007). Therefore, it could be adequate to test the food and beverage pairings in real life situations where they are most often paired (Lahne, 2018). Analogously, Meiselman (2013) has recommended that consumer studies should be performed outside laboratory settings; however, it could impact money and time investment. In consequence, in the last few years, several consumer methodologies have been implemented in natural consumption environments.

4. Social media

In recent years, the search for methods which involve spontaneous, non-directed evaluations in natural consumption environments has been the focus. The emergence of tools such as computing and big data are showing great potential in achieving this purpose (Lahne, 2018). For instance, social networks are becoming one of the most popular tools for social interaction (Hughes et al., 2012), as well as microblogs, which have become an important source for reporting real-world events (Zhou & Chen, 2014). In general, social media includes a wide range of platforms, including blogs, chat rooms, consumer-to-consumer e-mails, consumer product or service ratings websites and forums, internet discussion boards and forums, moblogs (sites containing digital audio, images, movies, or photographs), and social networking websites (Mangold & Faulds, 2009).

Social media is gaining relevance by being transformed into valuable sources of information and communication, including about food (Zhang et al., 2019). The main reason is that nowadays people tend to share information, pictures or videos of food, recipes or posts from family and friends sharing what they have eaten or will eat (Simeone & Scarpato, 2020). In addition, the high popularity of social media among consumers, including adolescents and young adults (Subrahmanyam et al., 2008) makes it a helpful tool for consumer research. Regarding these statements, the access to social media could allow a large amount of consumer data in natural environments to be collected from almost any eating situation. However, it has not been previously explored in the food and beverage pairing field, which could reveal the preferences for food and beverage pairings from a consumer perspective.

Social media as a source of information has been previously used in sensory and consumer science. For instance, Vidal et al. (2015) explored tweets from Twitter and investigated the main topics surrounding four eating situations (breakfast, lunch, snack and dinner). Saldaña (2019) also explored Twitter, by collecting all tweets containing the word “bacon” and analyzing the data through textual statistics. Holmberg et al. (2016) explored how, in which food context, and the type of food items that adolescents communicate food images in an image-sharing application (Instagram).

Some disadvantages should be considered in the use of social media as a source of information. First, a large investment of time is required to manually analyze the enormous amount that can be obtained. Second, in some cases it is not possible to obtain the specific consumer’s information, such as age and gender, due to the privacy settings of many user profiles. Finally, it has been stated that eating situations are more complex than products, so a more comprehensive and interpretative analysis is needed (Vidal, 2015).

Thesis justification and objectives

In the light of the literature review, some gaps in knowledge were pinpointed in the food and beverage pairing field. First, the question of whether there is a pattern of successful food and beverage pairings has been a concern among researchers, which has not yet been fully answered. Second, the influence of context and culture on consumer food and beverage pairing preferences and perceptions has been given little attention. And finally, there is still a need to develop appropriate methodologies to better understand consumer perception of food and beverage pairings.

This project will focus on two perspectives: the sensory and cultural aspects of food and beverage pairing, using beer as an object of study among other alcoholic beverages, such as wine. Nowadays, beer is strongly positioned in the Mexican drinking customs, along with other typical Mexican beverages. In fact, beer consumption in Mexico is the leader in terms of volume amongst all alcoholic beverages (Euromonitor, 2017). Additionally, the lower price of most beers, compared to wine, makes it a more affordable option when paired with foods. Therefore, beer allows almost all consumers to access gastronomic exploration (Martínez et al., 2017). Since more consumers are increasingly looking for new experiences in beer, attention should be paid to the way this beverage is paired with food (Donadini, et al., 2008). Analogously, beer has a wide range of flavors within fermented beverages, as well as wine. Also, both products share many sensory attributes, so a similar methodology could be used as a basis for exploring food and beverage pairing. This research will provide an exploration of non-traditional sensory and consumer science methodologies that could be successfully applied in the food and beverage pairing field.

Objective

This thesis aims to explore new methodological approaches to study consumer perception of food and beverage pairing from a cross-cultural perspective.

The specific objectives are:

- To explore social media as a source of information to study food and beverage pairing in four countries
- To explore the use of text and images from social media to understand food and beverage pairing in different situations.
- To study food and beverage pairing in different cultures through the use of projective mapping as a tool for exploration and visualization.

Structure of the thesis

To accomplish the objectives of the thesis, four studies (chapters) were included (Figure 1). Studies 1 and 2 address the first two objectives, respectively, whereas studies 3 and 4 address the third objective.

Figure 1. General structure of the studies performed in the thesis

The thesis contains four chapters focusing on different aspects of pairing. The first chapter focuses on the research of food and beer pairing using social media as a source of information. The chapter deepens into the culture as a driver of food and beverage pairing preferences by comparing four Latin American countries (Mexico, Argentina, Colombia, and Peru) in order to understand if there exists a pattern of successful food pairings across consumers in different cultures.

The second chapter focuses on the information obtained from text and image-based platforms as an element to understand and identify some of the most popular food and beverage pairings from different eating situations. Although texts could provide a verbal description of food experiences, images offer the possibility of exploring the consumption context, leading to a better understanding of food-beverage pairing and the situations in which these pairings occur among Mexican consumers. The identification of a set of popular foods and beverages from chapters 1 and 2 was used for the development of the third chapter.

Chapter 3 explores projective mapping as a tool to create food and beverage pairing maps amongst Mexican participants. Projective mapping was adapted, to where the proximity between products in the map represented food and beverage pairings. This chapter provided evidence that projective mapping could be a valuable tool to analyze and visualize consumers' food-beverage pairing data by analyzing the distances between food and beverages. Finally, given the lack of cross-cultural studies in the food and beverage pairing field, chapter 4 explores the influence of culture. Two cultures from different countries (Mexico and Norway) were assessed by applying the adaptation of projective mapping and comparing those two different nations' food and beverage pairings. The thesis concludes with food and beverage pairing results, showing how the methodologies used led to a better understanding of the act of pairing and how our food and beverage perceptions rely both on the culture we belong to and our consumption habits.

Chapter 1. Food and beer pairing from social media

Outcomes of chapter 1:

- Oral presentation at the 14th SENSOMETRICS 2018, Montevideo, Uruguay, 2018.
- A research article published in Food Research International in 2019:

Arellano-Covarrubias, A., Gómez-Corona, C., Varela, P., & Escalona-Buendía, H.B. (2019). Connecting flavors in social media: A cross cultural study with beer pairing. *Food Research International,* 115, 303-310. https://doi.org/10.1016/j.foodres.2018.12.004.

Food Research International 115 (2019) 303–310

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Review

Connecting flavors in social media: A cross cultural study with beer pairing

Araceli Arellano-Covarrubias[a,*], Carlos Gómez-Corona[b,**], Paula Varela[c], Héctor B. Escalona-Buendía[a,*]

[a] Sensory and Consumer Laboratory, Biotechnology Department, Universidad Autónoma Metropolitana, Av. San Rafael Atlixco No. 186, Mexico City 09340, Mexico
[b] XOC editorial, Calderón de la Barca 359, Mexico City 11559, Mexico
[c] Nofima AS, P. O. Box 210, Ås 1431, Norway

ARTICLE INFO

Keywords:
Social media
Flavor pairing
Food pairing
Beer pairing
Cross-cultural
Latin America

ABSTRACT

Culture is an important driver of food preferences and largely determines exposure to ingredients combinations. The cultural variety in culinary practices across countries raises the question of how flavor combinations are built and how they transcend individual differences in consumers' preferences. For example, in Latin America, despite having similar cultures and language, the diversity in culinary practices leads to different flavor combinations across nations. Therefore, we hypothesize that each country will show different preferences in flavor combinations that could be understood by social media exploration as an innovative approach.

One study was conducted exploring social media in four countries (Argentina, Colombia, Peru, and Mexico) on a one-year basis, using a list of fifty-seven keywords associated with beer flavors. In a first analysis, the list of mentions from consumers was categorized in frequencies of flavors per country and analyzed using correspondence analysis (CA) and agglomerative hierarchical clustering (AHC). Results showed that the countries could be clustered in three groups. Cluster 1 with Mexico and Peru, and the rest of the countries in different clusters. The co-occurrence of paired flavors in social media was used to build a similarity matrix that was analyzed using multidimensional scaling (MDS) in order to find a pattern of pairing per country. The obtained map was useful to understand the cultural differences in flavor paring per country. Overall, the analysis of flavor pairing through social media was an effective technique to access the structure of flavor pairing for beer in different countries.

1. Introduction

The act of eating and cooking has been at the center of human attention for thousands of years. According to Ahn, Ahnert, Bagrow, and Barabási (2011), the human being has historically faced the difficult task of identifying and gathering food that satisfies nutritional needs. However, our relationship with food is far more complex than nutritional; it combines at least two dimensions. The first one ranges from the biological to the cultural, and from the nutritional function to the symbolic (Fischler, 1988). The way we eat and combine food is affected by these dimensions. While food science has focused on the nutritional aspects, the cultural issues of food combination, or food pairing, has been less frequently explored.

1.1. Food pairing

In the last decade, food pairing has received more attention from several disciplines like gastronomy (Paulsen, Rognsa, & Hersleth, 2015), sensory science (Eschevins, Giboreau, Allard, & Dacremont, 2018), and history (Varshney, Varshney, Wang, & Myers, 2013). Most of the authors agree that food pairing states that if two ingredients share the major chemical compounds, the mixture of elements might taste (and smell) delicious when the foods are eaten together (Kort, Nijssen, van Ingen-Visscher, & Donders, 2010; Simas, Ficek, Diaz-Guilera, Obrador, & Rodriguez, 2017; Tallab & Alrazgan, 2016).

Klepper (2011) defined food pairing as a theory- In his article entitled Food Pairing Theory, the author mentions that the central hypothesis is that the more aromatic compounds two foods have in common, the better they taste together. This theory was developed to

* Corresponding authors at: Sensory and Consumer Laboratory, Biotechnology Department, Universidad Autónoma Metropolitana, Av. San Rafael Atlixco No. 186, Mexico City 09340, Mexico.
** Corresponding author at: XOC editorial, Calderón de la Barca 359, Mexico City 11559, Mexico.
E-mail addresses: araceli_ac50@hotmail.com (A. Arellano-Covarrubias), carlos@xoceditorial.com (C. Gómez-Corona), hbeb@xanum.uam.mx (H.B. Escalona-Buendía).

https://doi.org/10.1016/j.foodres.2018.12.004
Received 29 July 2018; Received in revised form 29 November 2018; Accepted 2 December 2018
Available online 05 December 2018

create new combinations of food that could be more pleasant for consumers and it has been popular among food scientists and chefs over the past years. Following this same approach, Tallab and Alrazgan (2016) state that volatile chemical compounds could be the main attributes responsible for food pairing theory, while basic tastes (sweet, acid, salty, bitter, and umami) play a secondary role (Burdock, 2004). This conclusion seems pertinent when it has been reported that 80% of food's flavor is determined by how our nose picks up volatile aromatic compounds, and the other 20% lies in mouth-feel and taste (Klepper, 2011).

Besides the demonstrated relevance of specific aromatic compounds in the perception of food pairing, other components of food, such as proteins, carbohydrates and lipids, can influence the perception of the food pairing. In other words, it is not only aroma that makes the pairing but also the texture, temperature, color, sound and trigeminal sensations (Varshney et al., 2013). Hence, it could be pertinent to restrict the study range of food pairing to its underlying dimensions or variables. Therefore, the pairing which focuses on aroma and basic taste, which seem the most relevant, could receive the name of flavor pairing.

1.2. Flavor pairing

When focusing only on flavor pairing, the study of the flavor compound profile is a natural starting point for a systematic search for principles that might underlie our choice of acceptable ingredient combinations (Ahn et al., 2011). This is based on the flavor pairing hypothesis which states that culinary ingredients with common chemical flavor components would combine well to produce pleasant dishes (Varshney et al., 2013). However, limiting the hypothesis only to the chemical components of ingredients could be rather incomplete, since not only the chemistry and physics of flavors are taken into account when we evaluate a flavor combination, and the perception of flavors that might differ in each culture. Also, there are multiple variables that influence food choice behavior, such as learning and memory, motivation and emotions, decision making, cognition, social behavior, and perception (Köster & Mojet, 2006) which is a dynamic process that should involve different scientific approaches.

Møller (2013) proposes that the gastronomic field should be studied from different perspectives and must include at least anthropological, psychophysical and neuroscientific perspectives. Starting from an anthropological perspective, the culture from which an individual belongs influences his food preferences and choices. For example, in the Mexican culture, children are taught to eat and appreciate chili, and transform an intense, pungent and hot sensation into a pleasant one (Rozin & Schiller, 1980). For Harrington (2005a), the flavor combination of food and beverages of a specific location involves the environment, which includes geography and climate, and the culture, which is provided by the history and ethnic influences; both of these impact on the prevailing taste components, textures, and flavors in food and drink.

Culture and local ingredients influence flavor preferences and combinations, nevertheless, there might also be elements of universality in flavor and food combinations, which means that different foods in different cultures with similar sensory profiles will induce the same desires in different cultures (Møller, 2013). These aspects of the variety and similarity of flavor combinations across nations have raised the question of whether there is a pattern of successful flavor pairings. In this study the objective is to understand if there exists a pattern of successful flavor pairings across consumers of different cultures, using beer as the case of study. More specifically, we want to explore the beer flavor pairing in four different countries that we hypothesize will have different perceptions, and to understand the cultural influences responsible for flavor pairing in each nation.

The study is geographically limited to four Latin American countries, and beer was selected as the case study since it is a popular beverage across different countries in the region. It has been reported by Euromonitor (2017) that the beer market in Latin American countries is highly consolidated and is expected to keep growing over the next few years. Moreover, beer is one of the most commonly consumed alcoholic beverages in Latin American countries, which consequently have the potential to generate more diversity in their products and enable the pairing comparison between countries.

We propose researching flavor pairing of beer using social media as a method of extracting data in the selected countries. The main advantage of using social media to study flavor pairing is the fact that it provides instant access to a significantly vast amount of information in a specific time, and avoids the bias or limitation of asking people questions. In this sense, it allows us to collect spontaneous flavor pairings in the selected countries, which could be used in the future as an approach to further research into the flavor pairing hypothesis in different cultures, to create new beer flavor combinations that could be applied or even make a successful contribution to the product development field.

2. Materials & methods

Two social media studies were conducted, similar in methodology, but differing in specifics related to the empirical protocol and objective.

2.1. Countries and flavors selection

The selection of countries was carried out using the Google Trends site (Google Trends, 2018 https://trends.google.com/trends/), extracting the top four countries with the highest number of mentions in 2013–2017 for the words: pairing, beer, food, flavor, gastronomy, and combination. Flavors selection was also performed through Google Trends site from keywords associated with beer: "flavored beer," "craft beer," and "beer and flavor combinations". The query was carried out in the Spanish language and for each country. Despite the same meaning, some flavor names were included twice due to the language differences in some countries. For example, the word "peanut" had different names: "maní" for Argentina, and "cacahuate" for Mexico.

2.2. Social media data

Data was retrieved using Synthesio® (Synthesio social media listening platform, 2018https://www.synthesio.com/). Synthesio® is a paid platform that gives access to both social and mainstream media. It allows researchers to look for information with specific keywords, in 197 countries, over > 80 languages, and within a determined time frame. A great advantage of this platform is the unlimited characters that can be searched for and analyzed compared with other platforms. Specifically for this research, it allows geographical restriction of the search by country and even region. It also automatically accesses public demographic information such as gender and age, only when the social media user makes the profile public.

Regarding the data analysis, Vidal, Ares, Machín, and Jaeger (2015), in their study involving Twitter, proposed discarding all re-tweets to avoid inclusion of repeated data. However, for the aim of this study, the re-tweets and all the repeated information gathered were not eliminated, due to the assumption that if more than one user shares and publishes the same information, and specifically the same flavor pairing, the more accepted and more popular was the pairing between the users. For the current research, flavor pairings are represented by the associated flavor names in mentions extracted from social media data, as a mechanism of approach to obtain the more frequent flavor pairings within social media users.

2.3. Experimental protocol

2.3.1. Study 1 - Beer flavor pairing in social media

In this study the objective was to explore the pairing between beers and other flavors. A Boolean search was performed in Synthesio®

platform for each of the selected countries. The time frame was set on a year's basis: July 18, 2016, to July 18, 2017. For the Boolean search (Supplementary Table 1) the words "beer" and "beers", were associated with "flavor", "taste", "drink", "to drink" and the list of sixty-five flavors retrieved from Google Trends, including double flavor searches due to different names in some countries (e.g. Plátano for Mexico and banana for Argentina).

2.3.2. Study 2 - Flavor pairing per country

In study 2 the objective was to gain a greater understanding of the pairing between flavors per country, based on the same list of sixty-five flavors. For this research, using the Synthesio® platform, the Boolean search was made as an association between paired flavor-related words (Supplementary Table 2). The first search criteria were defined by the main keyword, corresponding to the first of the sixty-five selected flavors, related with any of the sixty-four remaining flavors, with no > 9 words of distance (connector "NEAR/9") between them, which is the distance limit between word searches in Synthesio®; they were also associated with the keywords "flavor", "taste", "drink", "to drink", "flavors", "combine", "food", or "eat", in order to restrict the searches within food and beverages.

Data collection was performed in July 2017.

2.4. Data analysis

For both studies, the information contained multiple phrases, tweets, Facebook publications, and extracts from forums or blogs, where the keywords (flavor-related words) were mentioned by users. The data retrieved included an ID number for each mention, the country and date when the mention was published, the website name where it was posted, the URL from which it was extracted, and the user name and gender, if available. For both studies, the information could be downloaded in complete format (e.g. all the tweets by country) in a summary table of frequencies. Word counting was applied to all data (social media and mainstream) to obtain the more popular flavor-related word associations in each country, as it has been a common method for analyzing information about food studies involving Twitter (Platania & Spadoni, 2018).

2.4.1. Beer flavor pairing analysis

For this study, all the social media mentions were categorized in frequencies of flavor-related words per country through an automatic count using Synthesio®, some flavor-related word frequencies were grouped due to their similar nature: the group "berries" included cranberry, raspberry, berry, and blackberry; "stone fruits" included yellow peach, cherry, plum, and peach, and "cereals" included malt, oats, and wheat. Also, the flavor related-words with a different name in each country were grouped together, e.g. "grapefruit" included "pomelo" from Argentina and "toronja" from Mexico. After the grouping, percentages of each flavor name per country were calculated and flavor-related words with a lower occurrence value than 1% for all countries were discarded to avoid low frequency data.

Significant differences among countries in the frequency of occurrence of flavor names per country were evaluated using a chi-square test; additionally, the source of variation of global chi-square was identified using a chi-square per cell test (Symoneaux, Galmarini, & Mehinagic, 2012), calculated with a macro formula in Excel. The contingency table was analyzed through a correspondence analysis (CA) followed by an agglomerative hierarchical clustering (AHC) with the Ward algorithm on the first two factors where the identified clusters were described by the abrupt change of similarity level (Lebart, Piron, & Morineau, 2006). CA and AHC were performed with XL-Stat software version 2012.5.02.

2.4.2. Flavor pairing analysis

In study 2, with the data from each of the sixty-five flavor-related words, an automatic count for the remaining sixty-four flavor names was carried out using Synthesio® to obtain the frequencies in which 2 flavor-related words were combined in order to build a frequency matrix of flavor names per country. Some flavor-related word frequencies were grouped together due to their different names in the countries studied. A pre-treatment of the co-occurrence data was performed, building a similarity matrix to compute the proximity between flavor-related words using the Pearson correlation coefficient. The matrices obtained were the base used to carry out a multidimensional scaling (MDS) analysis in order to find a pattern of pairing per country through a sensory flavor map. The first two dimensions of each MDS were used to perform multiple RV coefficient analyses to test the similarities between two matrices; and finally, an agglomerative hierarchical clustering (AHC) with the Ward algorithm on the first two dimensions of MDS was performed. The statistical analysis was performed with XL-Stat software version 2012.5.02.

Finally, for both studies, in order to identify whether the more popular flavor-related words obtained from the previous statistical analyses belonged to flavor associations or only to associated words, a thematic analysis through familiarization with data and identification of relevant themes was performed.

3. Results

The discussion of the results obtained from the mentions on social media is divided into two sections: beer flavor pairing, and flavor pairing by country. The former focuses on the flavor pairings around beer across countries, while the latter establishes an insight into the structure of general flavor pairing in the different countries.

The countries with a higher number of mentions in Google Trends were Mexico, Argentina, Colombia, and Peru, and regarding the flavors selection, a final list of sixty-five flavors was obtained (including the double searches due to language differences).

3.1. Beer flavor pairing

The data retrieved through the Synthesio® platform was arranged by number of mentions; a total of 62,415 mentions were extracted. Mexico had the highest frequency with 27,544, followed by Argentina with 24,919, Colombia with 7267, and finally Peru with 2685 mentions. From the total number of mentions, 73% were categorized as social media data (e.g. Facebook, Instagram, etc.) and 27% were mainstream data (e.g. Corporate channels or Internet sites). From the media data, 50% were mentions extracted from Twitter, 16% from general news and magazines, 13% from Instagram, 5% from regional newspapers, 4% from blogs, and the remaining 12% were mentions from other types of social and mainstream media.

The extracted mentions of the sixty-five flavor names retrieved from Synthesio® were arranged into a contingency table of frequencies per country. After grouping the frequencies of flavor-related words with a similar nature and with different names in each country, a total of fifty flavor names were used to perform a new frequency table, and the percentage of occurrence for each country was calculated. Nineteen flavor-related words were discarded due to having < 1% occurrence of the total mentions for each country. Table 1 contains the frequencies of occurrence of the remaining 31 beer flavor-related words, according to the results of the Chi-square test. All of them differed significantly among the countries ($X^2 = 9492.96$; $p < 0.0001$), suggesting that cultural differences might influence the beer flavor pairing associations.

A correspondence analysis (CA) was performed on the contingency table data. Fig. 1 shows the first two dimensions that account for 95.85% of inertia. The axis 1 separates countries positioning Mexico, Colombia, and Peru close to each other and only Argentina is on the right-hand side of the graph. The axis 2 separates only Colombia from the other countries. The results of the hierarchical cluster analysis (HCA) on flavor-related words show seven beer flavor clusters, which

Table 1
Frequency of occurrence of the selected beer flavors.

Flavor	Mexico	Argentina	Colombia	Peru
Tequila	6024 (+) ***	1317 (−) ***	1709 (+) ***	205 (−) ***
Wine	3790 (−) ***	7191 (+) ***	1286	312 (−) ***
Coffee	2845	1856 (−) ***	789 (+) ***	173
Mezcal	2179 (+) ***	50 (−) ***	83 (−) ***	6 (−) ***
Chocolate	1338 (+) ***	829 (−) **	193 (−) ***	98 (+) **
Cereals	1307	959	306	113 (+) ***
Floral	1281 (+) ***	501 (−) ***	131 (−) ***	104 (+) ***
Lime	1205 (+) ***	645 (−) ***	213	116 (+) ***
Cheese	1096 (−) ***	1301 (+) ***	226 (−) ***	49 (−) ***
Chili	1081 (+) *	723	158 (−) ***	110 (+) ***
Fruity	931 (−) **	832 (+) ***	189	66
Sweet	860 (−) ***	990 (+) ***	167 (−) ***	56
Berries	691 (+) ***	135 (−) ***	88	14 (−) **
Woody	627 (−) **	607 (+) ***	84 (−) ***	41
Yeast	576 (−) *	534 (+) ***	73 (−) ***	47
Honey	517 (−) ***	556 (+) ***	70 (−) ***	47
Hop	486 (−) ***	557 (+) ***	85 (−) ***	42
Apple	470 (−) ***	699 (+) ***	71 (−) ***	38
Pineapple	456 (+) ***	120 (−) ***	75	32 (+) *
Acid	454 (+) **	243 (−) ***	62 (−) **	62 (+) ***
Bitter	435	330	136 (+) ***	23
Orange	419 (−) ***	660 (+) ***	70 (−) ***	36
Butter	400 (+) ***	100 (−) ***	49	25
Mango	386 (+) ***	113 (−) ***	107 (+) ***	26
Pecan	344 (+) ***	207	22 (−) ***	13
Coconut	336 (+) *	207	64	12
Strawberry	330 (+) ***	36 (−) ***	44	18
Peanut	196 (−) ***	605 (+) ***	38 (−) ***	10 (−) **
Stone fruits	199 (−) ***	258 (+) ***	42	13
Pepper	171 (−) ***	177	74 (+) ***	30 (+) ***
Hibiscus	246 (+) ***	32 (−) ***	32	33 (+) ***

Effect of the chi-square cell per cell test (+) or (−) indicate that the observed value is higher or lower than the expected value.
Values shown are the number of beer flavor mentions per country.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

highlight the cultural differences in beer flavor associations for each country. Argentina shows a relationship between wine, cheese, stone fruits, peanut and sweet. Colombia is related to tequila, mango, bitter, pepper, and coffee. And finally, Peru and Mexico in the central zone of the map, are surrounded by chocolate, lime, pineapple and coconut, establishing similarity between their beer flavor associations. These associations were confirmed by the AHC performed on the countries, where Mexico and Peru were grouped in the same cluster, while the rest of the countries were grouped in individual clusters.

3.2. Flavor pairing

The flavor pairing data, represented by the associated flavor names, were arranged in a 65 × 65 flavor matrix per country, showing the frequencies where each two flavor-related words were combined. After grouping the frequencies of the flavor-related words with different names in each country, a 57 × 57 flavor matrix per country was arranged, and a similarity matrix per country was performed; MDS analysis was carried out for each matrix. Kruskal's stresses for the first two dimensions of the MDS analysis of each country were 0.354, 0.365, 0.365, and 0.371 for Mexico, Argentina, Colombia, and Peru, respectively. According to Borg and Groenen (1997), Kruskal's values < 0.20 can be considered as an acceptably precise MDS solution, however, higher values might also be acceptable for the representation of the data if the decrease in stress begins to be less pronounced in the stress vs. dimensionality graph, when essentially the MDS analysis only scales the noise of the data. For all the matrices studied, the decrease is shown between two and three dimensions, and for interpretation purposes of the flavor maps, results for two dimensions were chosen. RV coefficients between each pair of matrices were used as a measurement of similarity, as Vidal, Jaeger, and Ares (2014) had previously reported that RV coefficient is a good predictor of similarity between pairs of sample configurations. Blancher, Clavier, Ergoroff, Duineveld, and Parcon (2012) proposed an RV coefficient higher than 0.95 to consider stability of sample configurations. The values of the RV coefficients in the present study (Table 2) are generally low, showing that matrices obtained are not similar to each other and, consequently, that flavor associations are different in each country.

The agglomerative hierarchical clustering (AHC) analysis was

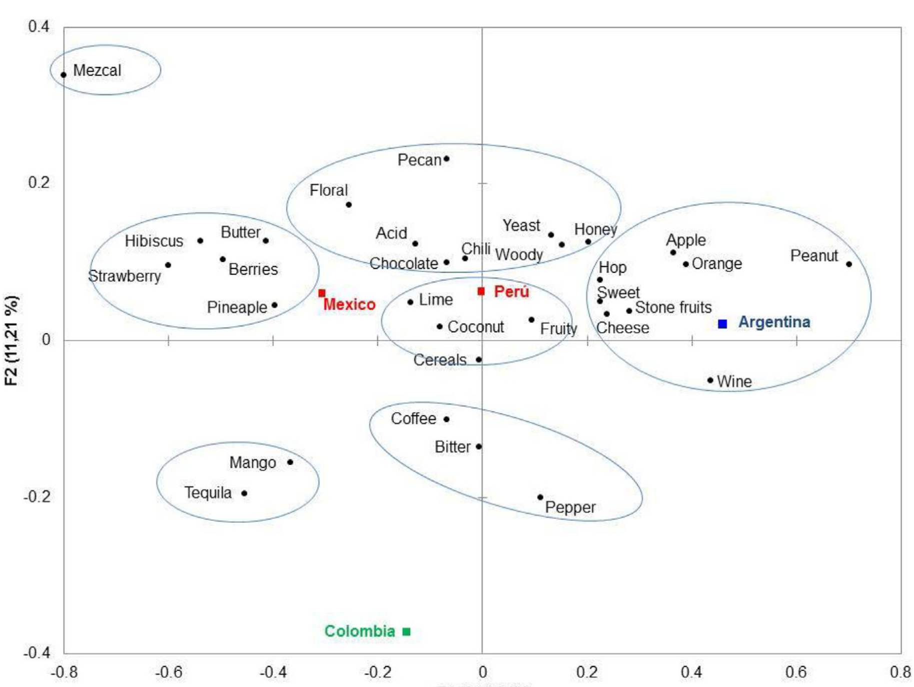


Fig. 1. CA of beer flavors in black circles and countries in squares. The hierarchical clustering of the CA shows that flavors can be clustered in 7 groups. Hierarchical clustering for countries grouped Mexico and Peru (in red) in the same cluster, while Argentina (in blue) and Colombia (in green) are grouped in individual clusters. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2
RV coefficients results of pair of matrices.

Countries	RV coefficients	*P*-value
Mexico-Argentina	0.20	< 0.001
Mexico-Colombia	0.29	< 0.001
Mexico-Peru	0.29	< 0.001
Argentina-Colombia	0.32	< 0.001
Argentina-Peru	0.01	0.846
Colombia-Peru	0.18	< 0.001

The closer the RV coefficients to zero, the more dissimilar are the pair of matrices.

performed to link the flavor words with similarities within the countries and, consequently, to find the flavor-related words being paired with greater frequency. Results of the AHC of the two first dimensions of MDS grouped the flavor-related words in 10, 11, 12, and 10 clusters for Mexico, Argentina, Colombia, and Peru, respectively (Supplementary Table 3). The words tequila, mezcal, and chili were grouped for all countries in the same cluster, except in Mexico where chili was grouped with some kinds of fruit like tamarind and grape, and also with the hibiscus flavor-related word. Tamarind and hibiscus were grouped together in all countries, except in Argentina. It is important to highlight that coffee and toasted were grouped together in all countries and a similar situation occurred with peanut and butter, however, these last combinations would probably refer to either an intrinsic characteristic of coffee or to the known product "peanut butter" instead of a common flavor pairing. Flavor- related words directly related to beer (yeast, malt, and hop) were grouped in a separate cluster only in Mexico, while in the rest of the countries they were spread in different clusters. Finally, alcoholic beverage flavor names (tequila, mezcal, and wine) were only grouped together in Mexico and Colombia. No other relevant patterns were found in the rest of the clusters within the countries.

MDS maps for each country are shown in Fig. 2, where all flavor-related words per country are distributed. On the Mexico map (Fig. 2a), the words related directly to beer (yeast, malt, and hop) and alcoholic beverages are distributed on the right side of dimension 1, while on the left side of the same dimension the spices and seasoning flavor-related words (vinegar, cinnamon, pepper, ginger) can be found. On the negative side of dimension 2, all berries are positioned on the map, and finally, on the positive side of this dimension, some of the words related to cereals and seeds (wheat, pecan, peanut) can be found. The results of Argentina's flavor map (Fig. 2b) show in the right lower quadrant all words related to beer and alcoholic beverages (yeast, malt, hop, wine, tequila, mezcal, agave), while on the left upper side, all the stone fruits are distributed (peach, plum, yellow peach, cherry); spices and seasoning flavor-related words like cinnamon, ginger, and pepper are distributed on the upper side of dimension 2. Results for Colombia (Fig. 2c) show on the upper side of dimension 2 the words related to alcoholic beverages and beer; in the right lower quadrant, all berries and stone fruits are distributed, whereas in the left lower quadrant the spices and seasoning flavor-related words are positioned. The results of the flavor map of Peru (Fig. 2d) show on the right side of dimension 1 some words related to alcoholic beverages (mezcal, wine, and tequila) along with some acidic (pineapple, orange, lime, grape) and semi-acidic fruits (peach, apple, plum, mango), while on the upper side of dimension 2 are distributed some beer flavor-related words like malt and hop, along with some floral names (floral and hibiscus). Finally, in all the maps, the words fruity and sweet are positioned at the center of the map.

From the MDS analysis, and for each country, the greatest distance of all the combinations of two flavor-related words was extracted and an average was calculated. The greatest average distance obtained was 1.637, and the associations with a value of no > 0.1637 distance were extracted, which correspond to 10% of the average distance. Those word associations were considered the most commonly paired flavor-related words (Table 3). The extracted number of pairings for each country were 35, 31, 32, and 31 for Mexico, Argentina, Colombia and Peru, respectively. The flavor-related words that were most commonly paired in all countries were cinnamon-ginger and coffee-toasted; ginger-pepper, tequila-mezcal, malt-hop, and butter-peanut were also common flavor-related words paired in the countries. Moreover, a small number of word associations that were frequent in two countries are shown, like **lime-orange** for Mexico and Argentina, and **cranberry-fruity** or **cinnamon-pepper,** for Colombia and Peru. The remaining paired combinations that were not repeated within the countries are not shown in Table 3 for the sake of length, but the interested reader can contact the authors for more details.

4. Discussion

A significant amount of information was extracted using Synthesio®. Sampling size (62,415 mentions) was more prominent than the information we could access through traditional consumer research. According to the website wearesocial.com (Wearesocial, 2018), the number of Internet users for Mexico is 85 million, for Argentina 34.79 million, for Colombia 31 million, and for Peru 22 million. These numbers seem to match the number of extracted mentions for the present study: Mexico had the higher number of mentions (27544), followed by Argentina (24919), Colombia (7267), and Peru (2685).

Almost half of the information gathered from social media was collected from Twitter, possibly due to the fact that tweets are predetermined as public when people register an account on the platform (Twitter, 2018). This in contrast from other sites such as Facebook or Youtube, which according to Lobzhanidze, Zeng, Gentry, and Taylor (2013) are not suitable to broadcast information due to their security mechanisms that allow access to published information only by restricted users.

4.1. Beer flavor pairing

Frequencies of occurrence (Table 1) show the flavor-related words with more extracted mentions in each country, but also the differences among the countries. For example, for Mexico, lime (1205 mentions) and chili (1081 mentions) have significantly more mentions when compared with the rest of the countries. This tendency could be explained by the fact that chili is eaten at almost every meal by Mexicans, being a representative flavor of the Mexican cuisine (Rozin, 1990). Another popular flavor-related word in Mexico is tequila, whose number of mentions exceeded 6000, and where it is a local product considered as "a quintessentially Mexican alcoholic beverage" (CRT, 2018).

In the case of Argentina, wine had a significantly high number of mentions (7191 mentions), and according to the WHO (World Health Organization, 2014) in the "Global Status Report on Alcohol and Health", within the countries studied, Argentina had the highest consumption (in liters of pure alcohol) of this product, constituting 48% of total alcohol consumption. Additionally for this country, the cheese flavor-related word reported the highest number of mentions among the countries, which has been widely reported as an ideal combination with wine and beer (Bastian, Payne, Joscelyne, & Johnson, 2009; Donadini, Fumi, & Lambri, 2013; Harrington, 2005b; Harrington, McCarthy, & Gozzi, 2010; Madrigal-Galan & Heymann, 2006). Regarding Colombia and Peru, the total number of mentions were lower than in other countries; however, tequila, wine, and coffee were the words with higher frequencies.

Donadini, Spigno, Fumi, and Pastori (2008) and Harrington (2005b) stated that the pairing of beer and food is not random; instead consumers recognize that beer goes better with specific flavors. Fig. 1 shows all flavor words widely related to beer within the countries, so in general **Argentina** is related to **wine**, **cheese**, **stone fruits**, and **peanut**. To illustrate the trend of the most cited flavor-related words

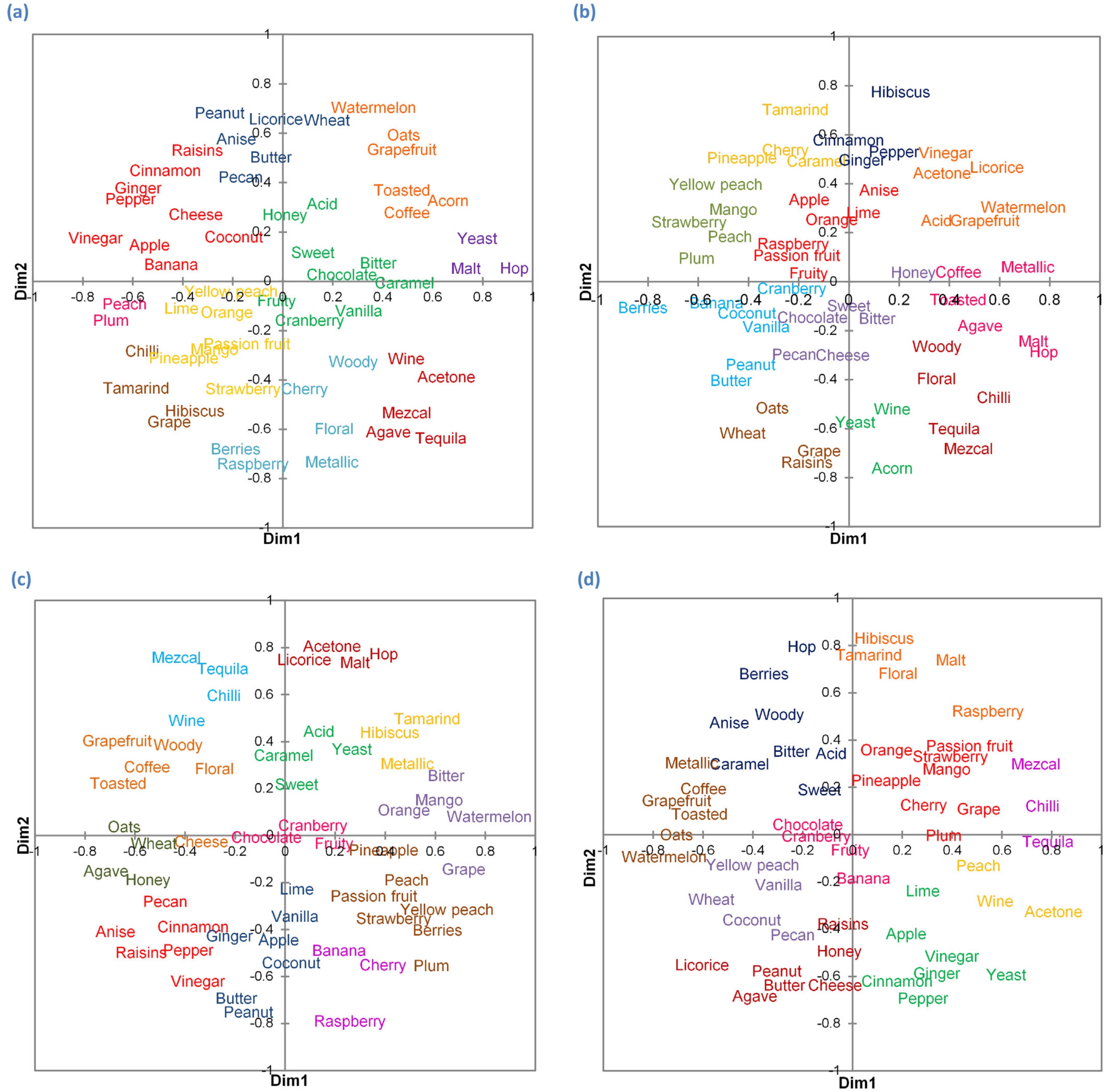


Fig. 2. Flavor maps. Two dimensional graphs for (a) Mexico, (b) Argentina, (c) Colombia, and (d) Peru. Kruskal's stress values are 0.354, 0.365, 0.365, and 0.371 for Mexico, Argentina, Colombia, and Peru, respectively. The hierarchical clustering of each MDS map is represented by similar colors.

obtained in Fig. 1, some relevant quotes were selected by searching for the flavor words within the beer flavor pairing database for each country.

Some of the mentions extracted that match with the flavor-related words tendency in Argentina are the following: "Enjoying with friends at #tabernadeodin, #honey #**peanut** #**beer** #cold"-Instagram; *"**beer** and **wine**, in that order"*- Instagram; and, *"Salami with **cheese** and **beer**"*- Twitter. These examples show some of the characteristic beer flavor associations in Argentina, and specifically, the peanut flavor has a cultural relevance within the country. According to the Cámara Argentina del Maní (CAM, 2018), peanuts are widely consumed in Argentina and are normally served free with beer as a part of tapas in bar and restaurants.

Regarding the beer flavor-related word associations for **Colombia,** we found that this country is related to **coffee**, **pepper**, **mango**, and **tequila**. Some of the mentions extracted that illustrate this behavior are: *"Kiko had for breakfast a kiwi, toast, **coffee** and a **beer**!"*-Twitter; *"Black bock **beer** style reduction of smoked **coffee** with sweet **pepper** and frosted with cinnamon and bitter cocoa"*-Instagram; *"Because there are days for a good **michelada beer** with **mango**"*- Instagram. However, in the case of tequila, we found out that Colombian people do not generally consume it "mixed" with beer; instead they mentioned the flavor-related word as a consumption option between multiple alcoholic beverages or as a sequence of beverages consumption: *"Yesterday, I drank **beer**, wine, **tequila**, whisky, schnapps, and piña colada, I went to bed at 7 am!"*- Twitter.

Table 3
Most paired flavors for Mexico, Argentina, Colombia, and Peru.

Mexico	Argentina	Colombia	Peru
Cinnamon – Ginger	Cinnamon – Ginger	Cinnamon – Ginger	Cinnamon – Ginger
Coffee – Toasted	Coffee – Toasted	Coffee – Toasted	Coffee – Toasted
Ginger – Pepper	Ginger – Pepper	–	Ginger – Pepper
Tequila – Mezcal	Tequila – Mezcal	Tequila – Mezcal	–
Malt – Hop	Malt – Hop	Malt – Hop	–
–	Butter – Peanut	Butter – Peanut	Butter – Peanut
Lime – Orange	Lime – Orange	–	–
–	–	Cranberry – Fruity	Cranberry – Fruity
–	–	Cinnamon - Pepper	Cinnamon – Pepper
–	–	Chili – Tequila	Chili – Tequila
Peach -Plum	Peach -Plum	–	–
Mango – Passion fruit	–	–	Mango – Passion fruit
Mango - Orange	–	Mango – Orange	–
Raisins -Anise	–	Raisins – Anise	–
Watermelon -Oats	–	–	Watermelon -Oats
Grapefruit - Oats	–	–	Grapefruit – Oats
–	Wheat - Oats	Wheat – Oats	–
–	–	Coffee – Grapefruit	Coffee - Grapefruit
–	–	Stawberry – Passion fruit	Strawberry – Passion fruit
–	–	Hibiscus - Tamarind	Hibiscus – Tamarind

The table shows the pairings that are repeated in at least two countries.

Finally, Peru and Mexico showed a similar flavor-related word association based on a large number of fruits, like **lime**, **coconut**, **pineapple** or **berries**; the words **chocolate** and **chili** were also related to both countries, indicating that these flavors could be highly paired with beer, as demonstrated by some of following extracted mentions: *"Mojito with frosty* ***lime*** *and lager* ***beer****"*- Instagram (Mexico); *"I enter this new restaurant: a* ***beer*** *and a* ***chocolate*** *cake, please. "Are we celebrating something?", they asked me"*- Twitter (Peru); *"A crazy* ***coconut*** *#coctel #****beer*** *#****coconut*** *#cucumber #****lime*** *#salt #corona #****chillipowder****"*- Instagram (Mexico).

4.2. Cultural flavor pairing

The flavor pairing matrices per country, in which two flavor-related words were combined, were not similar to each other (RV coefficients), and consequently, the preferences for certain flavor associations could be different in each country. As Møller (2013) states, our specific desires are dependent on the food of each country, but similar desires could also be found in different cultures, pinpointing the existence of potential universal patterns.

Ahn et al. (2011) questioned the possibility of the existence of some general patterns, above individual tastes and recipes, which could lead to successful ingredient combinations. In the present research, despite the cultural diversity of countries' cuisines, we could find some of these "universal elements" where the flavors, represented by the extracted words, were clustered together in all countries, or at least in two of them. For example, tequila and mezcal were grouped in all the countries, as were also the combination of coffee and toasted, and the pair peanut and butter. Besides these flavor-related word combinations found by the cluster analysis, the smaller distances on the MDS maps also show other general word associations like cinnamon-ginger, ginger-pepper, malt-hop, lime-orange, and cranberry-fruity.

Within the most commonly associated flavor-related words in all countries, the word association peanut / butter was frequently mentioned, but reviewing the information extracted for this pair of flavor-related words, it was found that people do not pair butter with peanut, instead, they consume the product known as "peanut butter." This example highlights the importance of the content analysis of information gathered as a method of a correct interpretation of social media data (Vidal et al., 2015). Besides the small number of similar flavor associations observed in the countries studied, no other patterns could be found, showing differences in food preferences and specifically in the flavor pairing within the countries.

Regarding the preferences and attitudes for certain products, Kim, Jun, and Kim (2018) stated that the cultural background could promote the similarities through the exchange of information within the population of the same culture, which implies that almost all consumer decisions are socially oriented (Jager, 2006), and where the use of social media in this research has a crucial importance in the exchange of information through a network of people within the countries.

On the other hand, and from a psychological perspective, it has also been stated that Western societies are analytical thinkers, which means that people from these societies would separate an object from its context (Kim et al., 2018); and, in the case of food preferences, Western societies could be less influenced by external factors like the presence of other cultures, but may also have more trust in the population of the same culture, which could explain the differences and popularity of the flavor associations within Latin American countries in the present research.

Within the cultural approach, it could be pertinent to research the flavor pairing as a multidisciplinary perspective, including the intrinsic chemical profile of each ingredient, as Ahn et al. (2011) state that modern Western cuisines follow the flavor pairing principle which is defined by the aromatic compounds' similarities between two flavors. Also, Simas et al. (2017) found that the flavor compounds of ingredients are strongly paired or bridged in Latin America, where the term "food-bridging" arises when two ingredients do not share a strong molecular affinity, but a third ingredient links the first two ingredients through a chain of chemical affinities. However, these similarities between the flavor pairings attributed to the chemical compounds may be due to either the intrinsic composition of flavors or to the influence of the culture to which each individual belongs.

The findings of this research demonstrate the diversity of the food culture that has been developed by humanity (Min, Jiang, Wang, Sang, & Mei, 2017), and also, that the culture to which we belong impacts directly on our perception of food and flavors (Harrington, 2005a), and consequently, on the preferences and choices across countries.

Finally, there is reported interest in new experimental beers beyond the traditional ones within Latin American consumers (Euromonitor, 2017), so this research could lead to the implementation of new products based on the beer flavor combinations obtained that could be successful in the beer market, and consequently have a positive economic impact in the field. The current research only proposes an insight, using social media as a tool of research, which could be exploited, whether for a better understanding of cultural differences (and similarities) in consumer behavior within countries, or for the application of the information gathered in order to propose new flavor combinations. However, further exploration should be carried out regarding social media data to guarantee that the information extracted reflects the accepted flavor combinations among consumers.

5. Conclusions

The results of this study show that social media analysis could be a good methodology to research the relationship between flavors in beer pairing across countries. It was possible to identify some flavor associations per country (associated to beer) and to explore the cultural relevance, as many differences and similarities between countries were identified. However, this approach has advantages and disadvantages. On the one hand, social media analysis enables the researcher to access a wide number of countries and regions in a way that could otherwise be very time and resource consuming. On the other hand, some consumers are being left out of the analysis, such as low income and senior consumers, due to the infrequent use of social media in those segments of the population, especially in developing countries like Mexico, Argentina, Colombia and Peru.

Acknowledgments

The authors wish to thank CONACYT-MEXICO for the scholarship (2017-2020 period) granted to Araceli Arellano Covarrubias for her PhD in the Biotechnology Postgraduate Program at the Universidad Autónoma Metropolitana, Mexico (520074/574751). The author P. Varela would like to thank the Norwegian Foundation for Research Levy on Agricultural Products, Norway for the research program "FoodSMaCK, Spectroscopy, Modelling and Consumer Knowledge" (2017-2020).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodres.2018.12.004.

References

Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A.-L. (2011). Flavor network and the principles of food pairing. *Scientific Reports, 1*(196).
Bastian, S., Payne, B., Joscelyne, V., & Johnson, T. (2009). Comparisons between Australian consumer's and industry expert's perceptions of ideal wine and cheese combinations. *Australian Journal of Grape and Wine Research, 15*, 175–184.
Blancher, G., Clavier, B., Ergoroff, C., Duineveld, K., & Parcon, J. (2012). A method to investigate the stability of a sorting map. *Food Quality and Preference, 23*, 36–43.
Borg, I., & Groenen, P. (1997). *Modern multidimensional scaling. Theory and applications.* New York: Springer.
Burdock, G. A. (2004). *Fenaroli's Handbook of Flavor Ingredients.* Boca Raton, FL: CRC Press.
Cámara Argentina del Maní (CAM) (2018). http://www.camaradelmani.org.ar/english/productos, Accessed date: 16 July 2018.
Consejo Regulador del Tequila, A. C. (CRT) (2018). https://www.crt.org.mx/index.php?option=com_content&view=article&id=69&Itemid=316, Accessed date: 18 May 2018.
Donadini, G., Fumi, M. D., & Lambri, M. (2013). Preliminary study investigating consumer preference for cheese and beer pairings. *Food Quality and Preference, 30*, 217–228.
Donadini, G., Spigno, G., Fumi, M. D., & Pastori, R. (2008). Evaluation of ideal everyday Italian food and beer pairings with regular consumers and food and beverages experts. *Journal of Institute of Brewing. 114*(4), 329–342.
Eschevins, A., Giboreau, A., Allard, T., & Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference, 65*, 18–27.
Euromonitor International (2017). Beer in Latin America. *Retrieved from: Euromonitor Passport database.* London: Euromonitor International.
Fischler, C. (1988). Food, self, and identity. *Social Science Information, 27*, 275.
Google Trends (2018). www.google.com/trends, Accessed date: 22 April 2017.
Harrington, R. J. (2005a). Defining gastronomic identity. *Journal of Culinary Science & Technology, 4*, 2–3.
Harrington, R. J. (2005b). The wine and food pairing process. *Journal of Culinary Science & Technology, 4*(1), 101–112.
Harrington, R. J., McCarthy, M., & Gozzi, M. (2010). Perceived match of wine and cheese and the impact of additional food elements: A preliminary study. *Journal of Food Service Business Research, 13*(4), 311–330.
Jager, W. (2006). Simulating consumer behavior: a perspective. In A. Faber, K. Frenken, & A. M. Idenburg (Eds.). *Environmental Policy and Modeling in Evolutionary Economics* (pp. 1–27). Netherlands Environmental Assessment Agency.
Kim, J. M., Jun, M., & Kim, C. K. (2018). The effects of culture on consumers' consumption and generation of online reviews. *Journal of Interactive Marketing, 43*, 134–150.
Klepper, M. (2011). Food pairing theory: A European fad. *Gastronomica, 11*(4), 55–58.
Kort, M., Nijssen, B., van Ingen-Visscher, K., & Donders, J. (2010). Food pairing from the perspective of the "Volatile compounds in food" database. *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium, Interlaken, Switzerland* (pp. 589–592). .
Köster, E. P., & Mojet, J. (2006). Theories of food choice development. In L. J. Frewer, & J. C. M. van Trijp (Eds.). *Understanding consumers of food products* (pp. 93–124). Woodhead Publishing.
Lebart, L., Piron, M., & Morineau, A. (2006). *Statistique exploratoire multidimensionnelle. Visualisation et inférence en fouille de données.* Paris: Dunod.
Lobzhanidze, A., Zeng, W., Gentry, P., & Taylor, A. (2013). Mainstream vs. social media for trending topic prediction-an experimental study. *Consumer and Communications and Networking Conference (CCNC), 2013 IEEE.IEEE* (pp. 729–732). .
Madrigal-Galan, B., & Heymann, H. (2006). Sensory effects of consuming cheese prior to evaluating red wine flavor. *American Journal of Enology and Viticulture. 57*(1), 12–22.
Min, W., Jiang, S., Wang, S., Sang, J., & Mei, S. (2017). A delicious recipe analysis framework for exploring multi-modal recipes with various attributes. *Proceedings of the 2017 ACM on Multimedia Conference* (pp. 23–27). .
Møller, P. (2013). Gastrophysics in the brain and body. *Flavour, 2*, 8.
Paulsen, M. T., Rognsa, G. H., & Hersleth, M. (2015). Consumer perception of food-beverage pairings: The influence of unity in variety and balance. *International Journal of Gastronomy and Food Science, 2*, 83–92.
Platania, M., & Spadoni, R. (2018). How people share information about food: Insights from tweets regarding two Italian regions. *International Journal on Food System Dynamics, 9*(2), 149–165.
Rozin, P. (1990). Getting to like the burn of chili pepper: Biological, psychological, and cultural perspectives. In B. G. Green, J. R. Mason, & M. R. Kare (Eds.). *Chemical Senses: Irritation* (pp. 231–269). .
Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion, 4*, 77–101.
Simas, T., Ficek, M., Diaz-Guilera, A., Obrador, P., & Rodriguez, P. R. (2017). *Food-bridging: a new network construction to unveil the principles of cooking*.
Symoneaux, R., Galmarini, M. V., & Mehinagic, E. (2012). Comment analysis of consumer's likes and dislikes as an alternative tool to preference mapping. A case of study on apples. *Food Quality and Preference. 24*, 59–66.
Synthesio® social media listening platform (2018). https://www.synthesio.com, Accessed date: 18 July 2017.
Tallab, S. T., & Alrazgan, M. S. (2016). Exploring the food pairing hypothesis in Arab cuisine: A study in computational gastronomy. *Procedia Computer Science, 82*, 135–137.
Twitter (2018). Help. Available at https://help.twitter.com/es/safety-and-security/public-and-protected-tweets, Accessed date: 8 May 2018.
Varshney, K. R., Varshney, L. R., Wang, J., & Myers, D. (2013). *Flavor pairing in Medieval European cuisine: A study in cooking with dirty data*.
Vidal, L., Ares, G., Machín, L., & Jaeger, S. R. (2015). Using Twitter data for food-related consumer research: A case study on what people say when tweeting about different eating situations. *Food Quality and Preference, 45*, 58–69.
Vidal, L., Jaeger, S. R., & Ares, G. (2014, November). What is the best parameter to estimate the degree of similarity between two-dimensional sample configurations? *Poster session presentation at Sensometrics 2014, Chicago*.
Wearesocial (2018). https://wearesocial.com/blog/2018/01/global-digital-report-2018, Accessed date: 15 May 2018.
World Health Organization (2014). http://www.who.int/substance_abuse/publications/global_alcohol_report/en, Accessed date: 18 May 2018.

Chapter 2. Text versus image-based methods

Outcomes of chapter 2:

- Oral presentation at the 13th Pangborn Sensory Science Symposium, Edinburgh, Scotland, 2019.
- A poster presented at the XVIII Congreso Nacional de Biotecnología y Bioingeniería, Guanajuato, México, 2019 (Not shown).
- A poster including the results of study 1 and 2, presented at the 13 SLACA Simposio Latino Americano de Ciencia de Alimentos, Campinas–São Paulo, Brazil, 2019. (Appendix 4).
- A manuscript submitted to the International Journal of Gastronomy and Food Science in 2021.

PAIRING BEER AND FOOD IN SOCIAL MEDIA: IS IT AN IMAGE WORTH MORE THAN A THOUSAND WORDS?

Araceli Arellano-Covarrubias[a], Carlos Gómez-Corona[b], Héctor B. Escalona-Buendía[a], Paula Varela[c]

[a] *Sensory and Consumer Laboratory, Biotechnology Department, Universidad Autónoma Metropolitana, Av. San Rafael Atlixco No. 186, 09340 Mexico City, Mexico*
[b] *XOC Estudio, Calderón de la Barca 359, 11559 Mexico City, Mexico.* carlos.gomezcorona@gmail.com
[c] *Nofima AS, P. O. Box 210, 1431 Ås, Norway.* paula.varela.tomasco@nofima.com

ABSTRACT

Food pairing has been widely studied to understand the patterns that explain how people pair different foods and ingredients and, therefore, to obtain successful pairings and good recommendations for consumers. Social media has become a common way of exchanging information; therefore, we proposed to use it as a tool for exploring beer-food pairing and eating behavior. Twitter and Instagram were selected as they are among the most popular platforms. Although texts from Twitter could provide an accurate verbal description of consumer's food experiences, Instagram could offer the possibility of exploring the consumption context through images, leading to a better understanding of consumers' eating behavior, with a focus on food and beverage combinations. We hypothesize that images from Instagram will provide further information than texts from Twitter, regarding beer-food pairing and consumption context. A social media study was performed in Mexico comparing texts vs. images, selected from a one-year period, and manually classified through content analysis. Foods extracted from images and texts were categorized into frequencies and analyzed using multiple correspondence analysis (MCA) and hierarchical clustering (AHC). MCA showed the most frequently mentioned foods paired with beer for each platform. Data extracted from images and texts about consumption context was also analyzed and categorized into frequencies according to several themes: consumption behavior, type of consumption, way of beer consumption, place of consumption, and consumption occasion. Data extracted from the two platforms was compared by using a chi-square test per theme. Several differences were found, depending on the social media platform, texts being the one with less extracted and meaningful information. In general, while texts provided less extracted and meaningful information, images offered more details regarding beer-food pairing and context of consumption, the same as beer information such as type, color, brand, and style. Overall, images gave more information on beer-food pairing compared to texts. The methods and results from this paper could be applied by culinary professionals, sommeliers, and researchers in the gastronomy and food and hospitality areas.

Keywords: Food pairing, Context of consumption, Beer, Social media, Instagram, Twitter.

IMPLICATIONS FOR GASTRONOMY

This study explores social media, specifically Twitter and Instagram, as a valuable tool for examining beer-food pairing information and getting an overview of its consumption behavior. Our findings offer a better understanding of how a specific culture pairs beer with different foods by gathering beer-food pairing information from images and texts, and specifically, the usage of images may have a non-explored value to gastronomy researchers. The use and analysis of images could be used to understand better not only food pairing, but food choice and consumption.

The information from this research could have multiple applications for culinary professionals, sommeliers, as well as for researchers in the gastronomy and food and hospitality areas. First, the proposed methodology for accessing beer-food pairing with social media gives cultural-relevant information of the different pairing combinations. Second, it highlights the cultural differences across beer-foods and meals pairing, and lastly it gives further insights into the effect of the context in the pairing situation (specially for the analysis of the social media images).

1. Introduction

Food pairing has been studied from different disciplines, such as gastronomy, sensory science, and history, to create new successful food and meal combinations and understand why people combine specific food and beverages. According to Paulsen et al. (2015), good pairing recommendations could be crucial for the success of foods, and beverages; additionally, Scander et al. (2018) stated that understanding the mechanisms behind beverage choice in different settings and cultural situations, and lifestyle backgrounds are needed to describe the intake patterns. Therefore, the study of social media could represent a valuable tool for exploring consumer food behavior, from which successful food and meals- beverage pairings could be identified.

Social media is one of the most accessible tools for sharing information, its popularity has increased a lot this past decade. Several studies reported that the use of this tool is now an integral part of the lives of many people, where consumers can easily gather information on which to base some of their decisions (Casaló et al., 2018), for example, helping consumers to decide what to buy or just to know more about certain products or brands (Powers et al., 2012). According to Mangold and Faulds (2009), consumers are turning away from traditional media such as television, magazines, and newspapers, which makes social media a valuable tool in consumer research.

Across different social media platforms, two of the most popular are Instagram and Twitter. According to Alexa's ranking web sites in Mexico (Alexa, 2021), which categorize by the number of visitors and site views, Twitter is positioned in 18th place while Instagram is in 15th place. These platforms use mainly text to share information in the case of Twitter and images for Instagram. Nowadays, and with the constant growth of social media use, researchers should create and apply new techniques involving social media analysis that could be used to better retrieve spontaneous responses of the consumers, in real-life settings (Vidal et al., 2015).

1.1 Twitter and Instagram

The Twitter platform was launched in July 2006, and by 2018, the platform already hosted 326 million active users, all over the world. This micro-blogging service encourage it users to publish anything that they need and have to say, as they claimed on their own web site: "Twitter is what's happening in the world and what people are talking about right now" (Twitter, 2021). As well as other micro-blogging web sites, Twitter has an important effect on early product adoption because of the immediate dissemination of post purchase quality evaluations (Hennig- Thurau et al., 2015).
Extensive research about food has been carried out using Twitter, such as describing Twitter publications regarding different eating situations (Vidal et al., 2015), influence of environment on food choices (Chen and Xining, 2014) and information sharing (Platania and Spadoni, 2018). In general, this platform could be a good tool for gathering information regarding context and additionally, the limit of characters that can be written in a tweet (280 characters) also facilitate the interpretation of the data (Zhou and Chen, 2014). The platform allows to add images, videos, and emoticons; however, it was originally created to connect and communicate people through texts, and it is still the main source of information in the tweets.

On the other hand, Instagram is a social media platform launched in 2006 (Instagram-press, 2019). This platform that has increased in popularity over the last years, has more than 1000 million active users (Wearesocial, 2019). According to the app developers, the main objective of Instagram is "to connect you with the people and things that matter to you" (Instagram, 2021). Instagram users are encouraged to post images for each individual or social activity that they are performing, such as daily activities, exercise, travel, parties, work, and food consumption, being this last the one that usually attracts the attention of users. In other words, it is an image-based social media platform that as a conventional wisdom, is mostly used for self-promoting and social networking with friends (Hu et al., 2014).

In their study, Hu et al. (2014) categorized a sample of Instagram images and found out that the *food* category contributed to more than 10% of the published images, only below *selfies (24.2%), friends (22.4%),* and *activities (15%)* categories. Taking pictures of food has become widespread among consumers and raises several questions, such as what kind of food images are posted (including the most popular food-beverage combinations) and which are the consumer's motivations to post them. Sester et al. (2013) stated, that answering all the questions implies the observation of the context of a specific situation of food consumption. In the present research, texts from Twitter and images from Instagram are used as research tools to explore the context of consumption of users.

1.2 Context of consumption and food pairing

The consumption context, according to Meiselman (2006), is defined as the physical, social, and situational conditions in which consumers eat food and beverages. Context of consumption is difficult to observe within traditional consumer tests due to different aspects, in which time investment, cost, recruitment of representative samples, and the simulation of a natural environment are the main issues. Additionally, it is well reported that people do not "act normally" when they are aware of being observed (or being interviewed) and consequently, the results could be biased. In fact, people could be more honest when interacting with a computer rather than with a human interviewer (Gnambs and Kaspar, 2015). So, when venturing into new techniques and tools for gathering information, such as social media, researchers could observe real food behavior from people in their natural context. Social media could offer instantaneous access to a large and representative consumer sample, as Meiselman (2013) states, this aspect meets a real need for consumer science research.

Considering this social phenomenon, using social media as a source of information could be a useful tool when exploring consumer behavior in real-life situations. According to Galiñanes et al. (2019), almost all the research on human eating behavior has been focused on food items instead of food combinations, which could contribute to misleading results. That is the case of food pairing, which has been a popular topic in the last decades, in which researchers have been looking for a pattern that could explain how people pair different ingredients, and consequently to find successful pairings for consumers (Ahn et al., 2011; Varshney et al., 2013).

Food Pairing Theory states that the more aromatic compounds two foods have in common, the better they taste together (Klepper, 2011). However, it is complicated to determine universal guidelines for good pairings due to the complex nature of the sensory interactions between food and beverages (Paulsen, 2015). Therefore, volatile compatibility is not the only answer to good pairings (Galmarini, 2020). In general, food pairing has been widely studied when pairing wine and cheese (King and Cliff, 2005; Bastian et al., 2010; Harrington and Seo, 2015), chocolate with different beverages (Donadini et al., 2012), and the pairings of other foods such as olive oil (Cerretani et al., 2007) or banana (Traynor et al., 2013). However, in the case of beer food pairing, little research can be found (Donadini et al., 2008; Donadini et al., 2013; Eschevins et al., 2019; Paulsen et al., 2015; Martínez et al., 2017).

Galmarini (2020) stated that food-pairing field needs a consumer-oriented approach to better understand what makes a good combination, and despite food pairing had been studied by using traditional sensory methodologies, the usage of different social media has not been explored, which arises an opportunity to gather beer food pairing information through images and texts. On our previous paper entitled “Connecting flavors in social media: A cross-cultural study with beer pairing” (Arellano-Covarrubias, A.; Gómez-Corona, C.; Varela, P., & Escalona-Buendía, H.B., 2019) we accessed the structure of food pairing for beer through the analysis of social media platforms and mainstream data in different countries. Results showed that the platforms with a more substantial number of mentions were Twitter and Instagram. Facebook did not show high number of mentions due to the characteristics of the platform, in which users usually made private their profiles so only their “friends” could access to their publications, contrarily from Instagram and Twitter in which the profiles, in general, are public so anyone could access to the user’s information/publications. In the present study, we research and compare the information extracted from texts versus images (from Twitter and Instagram, respectively), to understand which one provides a better understanding of beer-food pairing and more information about context of consumption. We hypothesize that, in general, texts from

Twitter are less informative than images from Instagram in the case of beer food pairing and context of consumption.

2. Materials & methods

The data for the present study was extracted using Synthesio® (Synthesio® social media listening platform, 2018). Twitter and Instagram publications related to beer and flavor/food combinations were selected from a year's base (July 18, 2016, to July 18, 2017) of our previous study. In this previous research, all publications were searched from a list of sixty-five popular flavors/foods and words related to beer (e.g., beer, beers) and associated with food consumption words (e.g., flavor, food, eat, food combination, etc.). As a result, all kinds of posts from social media and mainstream data (related to beer/food combinations) were extracted. In the present research, to test the proposed methodological approach, the analysis of texts (from Twitter) and images (from Instagram) was limited to Mexico. For further information about the extraction procedure of the Twitter and Instagram data, see Arellano-Covarrubias et al. (2019).

2.1 Data selection

From the Twitter and Instagram social media database, 200 tweets and 200 images from Instagram were extracted, all related to beer and foods. For each randomly selected social media publication, we accessed to the user profile who published, and the post was discarded if it comes from companies and/or publicity to avoid data bias, so that only the information published by consumers was selected. Re-tweet or re-post of images were also discarded (Vidal et al., 2015). The randomized selection was performed until an original publication was chosen, and achieved the target number of 200 Instagram posts, and 200 tweets. Only 13% of the selected tweets contained an image. For the purpose of this research only the text of the tweets was analyzed, and only images from Instagram.

2.2 Content analysis

Each text from the tweets and Instagram image related to beer were manually coded using qualitative content analysis (inductive coding) (Thomas, D.R., 2006). For understanding purposes, we will use “text” when referring to the text from the tweets and “images” to the pictures from Instagram. To report the user characteristics, the gender information was extracted, when available, by accessing to the public profile of the user.

For beer-food pairing extraction, each text was analyzed and extracted all the food associated with beer, where foods are represented by the food names mentioned in the publications. In the case of the images, we accessed the original image and extracted all foods, also related to beer, that could be seen in the picture. The frequency of occurrence was calculated for all foods and a contingency table from both texts and images was created. For a better understanding of this research, we will use the word “food” to refer to both food names extracted from texts and to the foods extracted from analyzing images.

Regarding beer context of consumption, all images and texts were analyzed and classified according to consumption behavior themes and subthemes. The election of themes and subthemes were performed by one researcher, and then agreed by two additional researchers, until a consensus was achieved. To perform the classification of the texts and images, each publication was assigned to a *subtheme* of each theme according to the content analysis, and a percentage of occurrence table was created. Additional information from texts and images, such as hashtags, text descriptions, or image titles, was also considered to perform the classification.

For both texts and images, whether the publication belonged to a negative, neutral, or positive consumption experience was registered. This classification was performed according to the context of the post and the words used in the publications, in which some feelings (or words related) such as happiness, excitement or pleasant, were classified as “positive”. In the case of complaints, bad moods, or sadness, the posts were classified as “negative”, and finally, “neutral” classification included all feelings that could not fit in positive or negative (indifference, lack of sympathy). If the intention of the post was not clearly identified, then it was classified as "neutral".

Finally, beer information (type, color, brand, and beer style) was also extracted if it could be identified in the text or seen in the image.

2.3 Data analysis

Gender was categorized in a contingency table for texts and images and each category was compared through multiple z-proportions tests. To obtain the beer pairings, a frequency table of foods was built for both texts and images, categorizing the food names that were mentioned in the case of texts, or seen in an image. Percentage of occurrence of each food per platform (text and image) was calculated, and food with less than 1% of occurrence was discarded to avoid low-frequency data. For each food frequency table, a multiple correspondence analysis (MCA) was performed followed by an agglomerative hierarchical clustering (AHC) with Ward algorithm on the first two factors of the MCA, and where the clusters were defined by the abrupt change in the similarity level (Lebart, 2006). An RV coefficient analysis was performed to the first two factors between both MCA to test differences within the coordinates.

All information regarding beer context of consumption was arranged in a percentage of occurrence table for themes and subthemes. Chi-square tests were applied to compare each theme within platforms, and multiple z-proportion tests were performed to test specific differences within subthemes.

Consumption experience (positive, negative, or neutral) and beer information (type and color), were categorized in a contingency table for both platforms and each category was compared through chi-square test, followed by multiple z-proportions tests within subcategories. Finally, regarding beer brands and styles, the percentages of occurrence were calculated.

All statistical analyses were performed with XLSTAT software version 2012.5.02 (Addinsoft, 2019).

3. Results

The results obtained from the information extracted from texts and images will be interpreted in two parts: beer food pairing and context of consumption. The first one focuses on the differences in the available information from images versus texts regarding food pairing with beer, while the second part provides an overview of the consumption context that could be extracted.

From the user's characteristics, the gender was categorized in a contingency table. In this research, the results of multiple z-proportions tests for gender (Table 1) showed no significant difference within platforms; however, considering that between 17.5% and 20% of the gender for each platform was unknown, a conclusion about gender behavior cannot be done.

Table 1

Chi-square and z-proportion test results for gender. Values shown are percentages.

Category	Subcategory	Twitter	Instagram	P-value
Gender	Both gender	0	**1**	1.000
	Female	31.5	**39**	0.142
	Male	**48.5**	42.5	0.269
	Unknown	**20**	17.5	0.608

Bold numbers indicate the higher percentage of occurrence for the respective platform.

3.1 Beer food pairing

For beer-food pairings, the frequency of occurrence was calculated for each food identified from texts and images. Some of the original translated texts are as follows, where the extracted food names and the type of beer are in bold letters: "For a hangover, I recommend a **Corona beer** in a frosted glass with ice, **salt**, **lime** and ready!"; "In summary: **coffee**, **whiskey**, **pizza**, **beer**, and a long series of memories, but always with good company".

In the case of images, all foods combined with beer that could be seen were extracted; for example, from Figure 1a, chili and lime were extracted, in Figure 1b, lime, chili, and mezcal were extracted, and, in Figure 1c, orange, peanut, jicama, and chili were extracted. Figure 1 includes the author's pictures recreation for illustrative purposes; the original images from the users are not shown due to privacy issues.

(a) (b) (c)

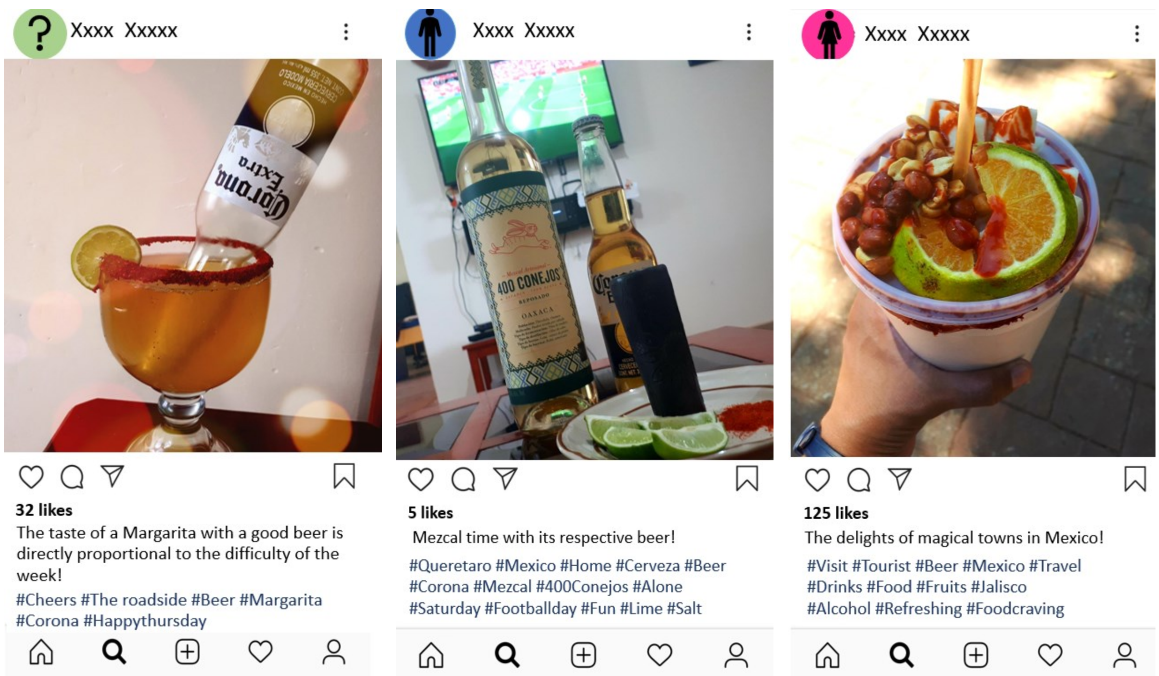


Figure 1. Images created by the authors. Original publications are not shown to protect the privacy of consumers. The images' comments are original; however, the identities of the consumers remain unknown.

The data retrieved from the content analysis of texts and images provided 85 foods that users paired with beer. These foods were arranged in a frequency table of food per platform, and the percentage of occurrence was calculated by using the number of total food mentions in each platform (for images: 1154, for texts 557). Finally, forty-nine foods with less than 1% of occurrence for both platforms were discarded, and a new table was created for the remaining 36 foods (Table 2), representing the most popular foods that consumers combined with beer. In general, images contained a higher number of mentions, except for salty snacks, pizza, coffee, wine, oats, chicken, chocolate, vodka, rum, and whisky, which had higher frequencies of occurrence for texts.

Table 2

Frequency of occurrence for foods per platform.

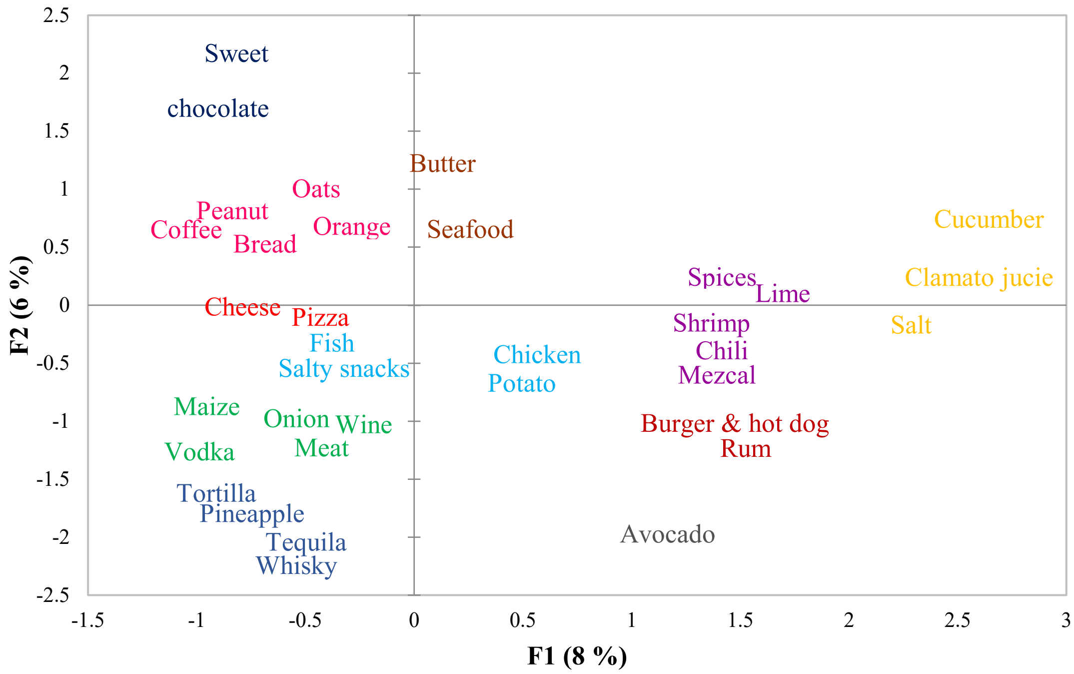
Food	Texts	Images
Chili	35	**136**
Salt	18	**92**
Lime	37	**91**
Spices	17	**90**
Cheese	39	**64**
Meat	28	**60**
Bread	26	**49**
Tortilla	18	**48**
Onion	7	**41**
Mezcal	6	**33**
Tequila	13	**28**
Potato	10	**27**
Tomato	0	**24**
Avocado	3	**22**
Peanut	5	**18**
Salty snacks	**35**	14
Shrimp	3	**13**
Cucumber	2	**13**
Pizza	**21**	8
Coffee	**16**	5
Wine	**13**	3
Oats	**7**	0
Clamato juice (tomato & clam)	11	**19**
Chicken	**25**	16
Orange	6	**14**
Chocolate	**18**	11
Burger & hot dog	6	**11**
Fish	10	**11**
Seafood	8	**10**
Pineapple	6	**9**
Maize	7	**8**
Butter	7	**8**
Sweet	7	7
Vodka	**9**	2
Rum	**7**	1
Whisky	**6**	1

Bold numbers indicate the higher frequency of occurrence for the respective platform. (n texts= 200; n images =200)

With the 36 foods with more than 1% of occurrence for each platform, a multiple correspondence analysis (MCA) was performed to create beer-food pairings maps. The RV coefficient between the first two factors of both MCA showed that the coordinates of the maps are not similar (RV=0.126; *p-value*=0.067), and consequently, that the MCA structures are also different. Figure 2 shows the food-pairing maps, considering the first two factors of the MCA. The results of the hierarchical cluster analysis (HCA) showed eleven clusters for texts and eight clusters for images, which illustrates the beer-food pairing information retrieved from each platform.

Some patterns within the clusters from both food-pairing maps were identified: lime, chili, and spices were grouped in the same cluster on both platforms. Also, pizza and cheese were clustered together, and additionally for images, pineapple was also included in the same cluster. Regarding texts information, no other patterns could be found, but in the case of images, all seafood was clustered together (fish, shrimp, seafood), while in another cluster, all vegetables were grouped together, with the potato food exception, which was clustered along with butter, burger, and hot dogs. Additionally for images, wine, bread, and cheese were grouped in the same cluster; and finally, meat and chicken were also grouped together. In general, food pairings that combined well with beer could be extracted from the clusters of each food-pairing map.

(a)



(b)

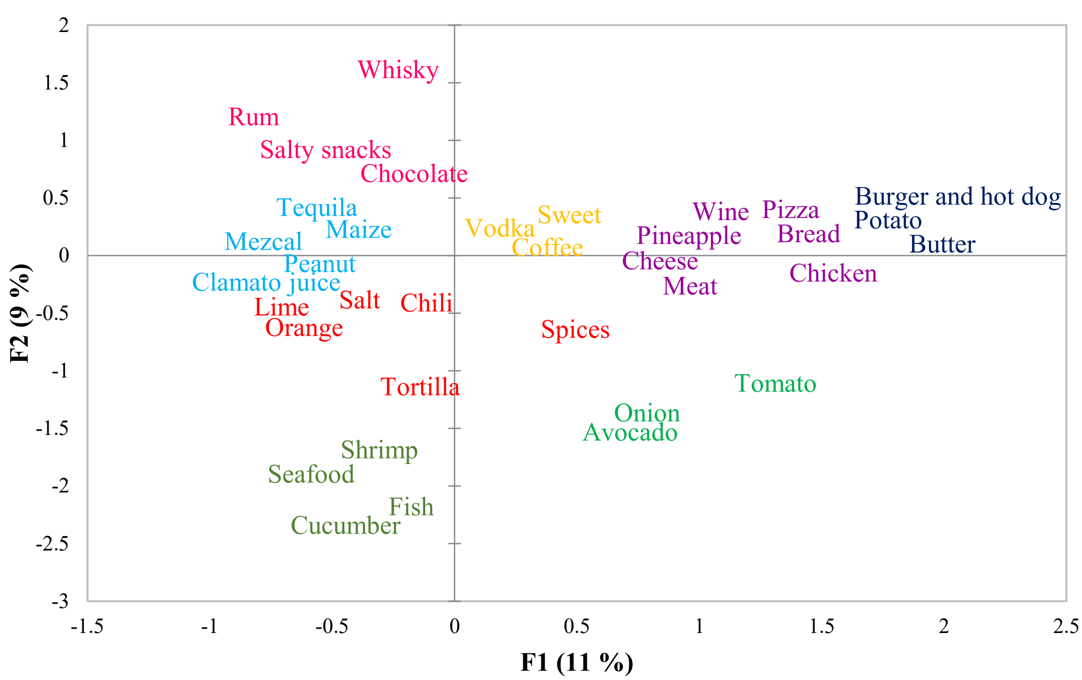


Figure 2. Food pairing maps for (a) texts and (b) images. The hierarchical clustering of each MCA map is represented by similar colors, in which foods were clustered in 11 groups (a) and 8 groups (b).

3.2 Context of consumption

Regarding the beer context of consumption, several themes and subthemes were selected after the author's consensus. The **themes** and *subthemes* were **consumption behavior** (subthemes: *consuming, craving, making plans, past consumption, and other/unknown*), **type of consumption** (subthemes: *individual, social, and unknown*), **way of beer consumption** (subthemes: *can, bottle, glass, and other/unknown*), **place of consumption** (subthemes: *restaurant/bar, home, other (beach/office), and unknown*) and **consumption occasion** (subthemes: *celebration, travel, frequent consumption, and other/unknown).*

Each image and text were categorized in one subtheme of each theme. For example, in Figure 1b, the user is consuming at the time of the post due to the title of the picture: "Mezcal time with its respective beer!". Also, the user is drinking beer directly from the bottle in a place which seems to be home (#Home); the hashtags "#Saturday, #Footballday" may suggest that the user usually consumes these products on Saturdays while watching TV, and behind the beer, we could see the place of consumption (#home).

Regarding texts, the extraction of the information was performed in a similar process but extracting the written information that users posted. An example of the extracted text is as follows: "I will sit in the armchair at home, eating nachos with cheese, and drinking beer!". In this case, the user is making plans, presumably for individual consumption ("I") while staying at home. More information could not be identified.

Context of consumption data showed differences in chi-square tests for all themes, while z-proportion tests showed differences in almost all subthemes, except for home and other (theme: place of consumption) and celebration and frequent (theme: consumption occasion) (Table 3).

Table 3

Chi-square and z-proportion test results for context of consumption. Values show the percentage of occurrence of subthemes identified through content analysis for images and texts

Theme	Subtheme	Texts (%)	Images (%)	P-value
Consumption behavior ($\chi^2_{(4,400)}$ = 79.534, $p<0.0001$)	**Consuming**	25	**67.5**	<0.0001
	Craving	**9**	0	<0.0001
	Making plans	**11**	3.5	0.006
	Past consumption	**20.5**	11.5	0.016
	Other/unknown	**34.5**	17.5	0.0004
Type of consumption ($\chi^2_{(2,400)}$ =27.143, $p<0.0001$)	**Individual**	**56**	40	0.002
	Social	21	**46**	<0.0001
	Unknown	**23**	14	0.028
Way of beer consumption ($\chi^2_{(3,412)}$ = 325.590, $p<0.0001$)	**Can**	0.5	**5.7**	0.0049
	Bottle	0.5	**44.8**	<0.0001
	Glass	10	**48.1**	<0.0001
	Other/unknown	**89**	1.4	<0.0001
Place of consumption ($\chi^2_{(3,400)}$ = 115.415, $p<0.0001$)	**Restaurant/Bar**	16	**62.5**	<0.0001
	Home	18	13.5	0.271
	Other (Sport games, Beach, Office)	4	8.5	0.097
	Unknown	**62**	15.5	<0.0001
Consumption occasion ($\chi^2_{(3,400)}$ = 32.998, $p<0.0001$)	Celebration	5.5	8.5	0.340
	Travel	3	**20.5**	<0.0001
	Frequent	39.5	34.5	0.365
	Other/unknown	**52**	36.5	0.002

Results of chi-square tests are shown for the respective theme. For z-proportions tests results, bold letters indicate the subthemes that were significantly different within platforms, while bold numbers indicate the higher percentage of occurrence for the respective platform. (n=200 for all themes for each platform, except for "way of beer consumption" theme for images, which n= 212 due to images showing more than one way of drinking beer).

Regarding the differences in beer consumption behavior theme, images showed more information when people were consuming at the present time (consuming), while for texts, most of the consumption behavior was unknown, while "craving", "making plans", and "past consumption" were found in lower quantities. In the case of the type of consumption theme from images, information about social consumption was obtained (e.g., "*Mezcal tastes better with a beer and good company*"), in which users mostly share images of spending time with friends, partners, or family. For texts, only individual consumption could be identified (e.g., *"My diet today: cake and coffee, cheese snack, beer, peanuts and a cigar*"), as the posts were mainly referred to the user's consumption.

For the way of beer consumption theme in images, it was able to identify if the users consume beer from a can, bottle, or glass, while for texts, it was unable to identify the way of consumption in most of the posts. Regarding the place of consumption for images users, most of them publish images while consuming beer in restaurants/bars, while for texts, the place from which people are posting is unknown. Regarding the consumption occasion theme, there was no significant difference for frequent consumption within platforms; however, image users share more information when traveling. Additionally, for text users, the highest percentage of occurrence for the consumption occasion was unknown (e.g., "*My tacos with guacamole, beer, tequila and whisky*"; "*Chicken wings, onion rings and beer, delicious!")*.

Experience (positive, negative, or neutral) and beer information (type and color) were categorized in a contingency table, and each category was compared through a chi-square test (Table 4). Experience, beer type, and beer color categories showed significant differences, and to test specific differences within platforms, several z-proportions tests were performed for each subcategory. For the experience category, significant differences were found in all subcategories where images users posted a higher percentage of publications with a positive experience when compared to texts, and texts had higher neutral and negative experiences than images; however, on both platforms, the percentages for positive experiences were higher than the neutral or negative ones.

For beer type, significant differences were found for industrial and unknown types of beer, where images users had the highest percentage of industrial beer consumption, while for texts, the highest consumption of beer type is unknown. For beer color, significant differences were found for blond, dark, two or more colors, and unknown color, in which images users obtained the highest percentage of blond, dark, and two or more beer colors, while for texts, the highest percentage was for unknown beer color.

Table 4

Chi-square and z-proportion test results for additional information. Values shown are percentages.

Category	Subcategory	Twitter (%)	Instagram (%)	P-value
Experience ($\chi^2_{(2,400)}$ =19.154, *p<0.0001*)	**Positive**	72.5	**89**	<0.0001
	Neutral	**18**	9	0.012
	Negative	**9.5**	2	0.002
Beer type ($\chi^2_{(3,400)}$ =113.184, *p<0.0001*)	Craft	9	14	0.157
	Industrial	12.5	**58**	<0.0001
	Both	0	1	0.477
	Unknown	**78.5**	27	<0.0001
Beer color ($\chi^2_{(5,400)}$ =179.597, *p<0.0001*)	Amber	1.5	3	0.500
	Blond	11	**53.5**	<0.0001
	Dark	9.5	**26**	<0.0001
	Two or more	0.5	**5**	0.014
	Other	0	1	0.477
	Unknown	**77.5**	11.5	<0.0001

Results of chi-square tests are shown for the respective category. For z-proportions tests results, bold letters indicate the subcategories that were significantly different, while bold numbers indicate the higher percentage of occurrence for the respective platform.

Regarding beer brand and style, images provided, in general, more information than texts. In the case of beer brand, 43 brands were identified from images and only 18 from texts; however, the highest percentage of occurrence for both platforms was for an unknown brand (81% for texts versus 28% for images). In the case of beer style, 14 styles from images and only 11 from texts were identified. The highest percentage of occurrence on texts belonged to an unknown style (80%), and it was followed by Pilsner beer with 8.5% occurrence. For beer styles for images, only 31% occurrence belonged to an unknown style, while the highest percentage (44.5%) was identified as Pilsner beer. Table 5 shows the different brands and styles that were identified from both platforms.

Table 5

Beer brands and styles identified from texts and images. Values shown are percentages.

Beer brands				Beer styles			
Texts (%)		Images (%)		Texts (%)		Images (%)	
Bluemoon	0.5	Affligem	0.5	Bock	0.5	Altbier Imperial	0.5
Calavera	0.5	Allende	0.5	India Pale Ale	1.0	American Pale Ale	1.0
Corona	6.5	Allende	0.5	Lager	1.0	Belgian Dubbel	0.5
Dirty Bastard	0.5	Becerro	1.0	Multiple styles	0.5	English Brown	0.5
Guinness	1.0	Berber	0.5	Pilsner	8.5	Imperial Stout	0.5
Heineken	1.5	Bocanegra	0.5	Porter	1.5	India Pale Ale	0.5
Házmela Rusa	0.5	Bohemia	1.0	Scotch Ale	0.5	Kölsch	0.5
Indio	0.5	Bud Light	0.5	Stout	3.0	Lambic	1.0
Minerva	3.0	Budweiser	0.5	Tequila Ale	1.0	Multiple styles	4.5
Mocachela	0.5	Corona	22.5	**Unknown style**	**80.0**	Munich	2.5
Modelo	0.5	Cucapá	0.5	Vienna	2.0	**Pilsner**	**44.5**
Multiple brands	0.5	Foca Parlante	0.5	Witbier	0.5	Porter	0.5
Noche buena	0.5	Fortuna	0.5			Stout	4.0
Patito	0.5	Heineken	4.0			Unknown style	31.0
Sierra Nevada	0.5	Honey Pale Ale	0.5			Vienna	7.5
Unknown brand	**81.0**	Házmela Rusa	0.5				
Victoria	1.0	Indio	2.0				
XX	0.5	La Bestia	0.5				
		Lindemans	1.0				
		Mezcalito Cococó	0.5				
		Michelob Ultra	1.5				
		Miller High Life	1.0				
		Minerva	2.0				
		Modelo	2.5				
		Modelo	0.5				
		Monolito	0.5				
		Multiple brands	5.5				
		Negra Modelo	2.0				
		Negra Modelo	0.5				
		Pacífico	2.0				
		Pulpo	0.5				
		Santta	0.5				
		Sol	1.0				
		Stella Artois	1.0				
		Tecate	2.0				
		Tecate	0.5				

Table 5 (continued).

Beer brands				Beer styles	
Texts (%)		Images (%)		Texts (%)	Images (%)
		Tempus doble malta	0.5		
		Unknown brand	**28.0**		
		Victoria	2.5		
		Vida Latina	0.5		
		Wasumara	0.5		
		XX	5.5		
		Young's Double Chocolate	0.5		

Bold letters and numbers indicate the highest percentage of occurrence of beer brand and style for each platform.

4. Discussion

The discussion is divided into three sections. The first one focuses on beer-food pairing information, while the second one focuses on the differences in the available information of the consumption context from texts and images. Finally, a short discussion section comparing image and text is added to highlight the importance of exploring both platforms as an information source of food-beverage pairing.

In this research, gender was no significant different within platforms. According to wearesocial (2019), the percentage of active women users for image platform (Instagram) is higher than active men users (women: 55%; men: 45%), while for text platform (Twitter), the percentage of active women users is lower than that of men (women: 35%; men: 65%). The results of multiple z-proportions tests showed that there was no significant difference, suggesting that both women and men post about beer to the same extent within platforms (and possibly also consume equally).

4.1 Beer food pairing

Table 2 showed the frequency of occurrence of foods that were combined with beer. The higher frequency of occurrence of foods extracted from images could be due that the main objectives of the platforms' usage are also different; while texts (Twitter) seem to be an opinion platform, images (Instagram) is for sharing experiences (Twitter, 2019; Instagram, 2019), which could have a direct impact on what kind of information people publish. Furthermore, the amount of registered information could reflect the data extraction methodology, from which the graphical characters such as emoticons, pictures, and videos were not considered for the analysis, in the scope of comparing the information for beer-food pairing from only texts versus images.

Although images had more mentions for most of the foods, chili, salt, and lime were frequently mentioned on both platforms combined with beer, and in accordance with our previous research, lime and chili had more extracted mentions for Mexico (Arellano et al., 2019). These similar results reflect how culture strongly influences beer-food pairing within the Mexican population. According to Lo Monaco and Bonetto (2019), all food norms and practices are transmitted between individuals and across generations over time, which could be the reason why some foods, such as chili, have been popular among Mexican consumers across generations. According to Spence (2018), chili occurrence has been widespread across many of the world's cuisines. Specifically for Mexico, Rozin (1990) and Katz (2009) stated that chili is the main characteristic of Mexican cuisine, and as expected, it could be reflected in their alcoholic beverage' consumption. In this sense, chili, salt, and lime foods could be part of the Mexican gastronomic identity, which according to Harrington (2005a), is a concept that arises because of environmental and cultural elements. A reflection of this behavior is the vast number of both images and texts of users that consumed "Micheladas", which are defined (with some variants according to specific regions in Mexico) as beer frosted with lime, salt, and chili, and which is widely known and consumed among Mexican people.

The main findings regarding alcoholic beverages were that Mezcal and tequila, which are characteristics products of Mexico, were identified more frequently on images than texts. Wine was more frequently identified on texts than images, despite the low sale of this beverage in Mexico (and consequently a low consumption), where until 2013, the sales of wine were only 11.11% of total sales of beer, in millions of liters (Euromonitor, 2014). However, even though wine is not a very popular beverage among Mexican people, it has been reported a growth in their consumption in Mexico (Euromonitor, 2014).

From both food and beverage maps, the clusters from texts were less informative than the clusters from images. Within the patterns, pizza and cheese were joined in the same cluster on both platforms, and additionally for images, pineapple was also included in the same cluster; in this line, Donadini et al. (2008) mentioned that pizza is compatible with beer. For images, some foods were clustered by categories, such as seafood and vegetables. Finally for images, wine, bread, and cheese were grouped together, and despite wine and cheese are not commonly paired with beer, they are widely accepted to consume together (Harrington & Hammond, 2005b; Harrington, 2008; Bastian et al., 2010; Harrington et al., 2010). So, in general, the food and beverage maps from images provided the greatest amount of information and a more meaningful interpretation regarding the combination of foods with beer.

4.2 Context of consumption

All information about the context of consumption and eating behavior was extracted from images and texts. According to the results, and despite text users were classified as sharing individual consumptions, some research has stated that Twitter users gratified the need to connect with other people (Chen, 2011). On the other hand, images seem to match with social consumption, and according to Thomé et al. (2017), this social interaction is perceived as a guide for beer consumption, that could shape consumer behavior and actual purchase/brand choice. Therefore, social circumstances seem to be highly relevant in how we consume our food or which food we decide to consume (Abbar et al., 2015).

For the way of beer consumption theme in images, users share pictures of drinking beer in a glass or directly from the bottle, while for texts, users do not specify the way of drinking, which could be due to the limit of characters for text, in which users should communicate with shorter phrases. Regarding the place of consumption, most of the images represented a consumption of beer in restaurants/bars, in line with Lee et al. (2015), who stated that image platform (Instagram) users record their daily events and traces (e.g., trips), creating a personal cyber documentary through fancy photos. In the case of the consumption occasion theme, there was no significant difference for celebration and frequent consumption within platforms, which agrees with Java et al. (2007), who found that daily routine posts are among the most common uses of Twitter.

In the case of beer information for texts, it was challenging to identify all information about type and color, while for images, in almost all posts, the information could be categorized with industrial and blond and dark beer having higher percentages of occurrences. In general, we could infer that consumers that posted images are (mostly) industrial beer consumers who like blond and dark beers. However, given that texts do not give more information to clarify which products the users consume, we cannot discuss it in greater depth.

Regarding beer brand and style, images provided an advantage over texts. It is a fact that not in all images the users described the type of beer that they were drinking, but if the beer brand could be identified in the image, the additional information was investigated in the official websites of the products. In contrast, if some beer information was not given for texts, then all information remained unknown. In general, more beer brands and styles were identified from images than texts; Corona beer was the second brand with a higher percentage of occurrence for both text and image platforms. Gómez-Corona et al. (2016), in their research on habits of beer consumption in Mexico, reported Corona beer as the most frequently consumed beer brand; this popularity of Corona beer on social media could be attributable to the fact that it is a leading brand of alcoholic beverage in the national market (Grupo Modelo, 2019).

4.3 Comparing text and image platform

To better understand the amount and type of information extracted from image versus text platforms, we must explore the usage of the original platforms. In the case of text, Twitter has been categorized as a microblogging site, which fulfills a need for a faster mode of communication that lowers the user's requirement of time (Java et al., 2007). On the other hand, Instagram is a photo-sharing mobile application that allows users to take pictures and share them on the platform. The usage of photographs highlights the importance of visual self-presentation of the users (Marwick, 2015).

Some differences between the platforms rely on the users' intentions/motives. In the case of Twitter, Java et al. (2007) found that the main user intentions are: daily chatter, conversations, sharing information, and reporting news. Twitter users usually share short messages, links, videos, and some hashtags in their tweets; however, words and images are the main tools to share information, activities, and experiences (García-León, 2019). So, in general, sharing information and social interaction are the main intentions of using Twitter.

In the case of Instagram (image platform), Sheldon and Bryant (2016) found four motives for using the platform: surveillance/knowledge about others, documentation, coolness, and creativity. Also, in 2015, Lee et al. found that Instagram users have five primary social and psychological motives: social interaction, archiving, self-expression, escapism, and peeking (Lee et al., 2015), while Baker and Walsh (2018) concluded that Instagram has become popular for self-presentation and public display. According to the previous research, social interaction, identity construction, and self-promotion are strong factors for using Instagram.

Although social interaction motive is similar for using Twitter and Instagram, the differences (sharing information for Twitter, and identity construction and self-promotion for Instagram) could explain that with images we accessed to a higher amount of information than texts regarding beer-food pairing and context of consumption, since pictures could reflect consumers lifestyles where capturing and sharing pictures plays a core role.

Photography in consumer behavior could be an important source of information for gastronomy field, from which researchers could access to users' daily activities and their food culture, such as Instagram users utilize pictures of all sorts of things to present their personalities, lifestyles, and tastes. (Lee et al., 2015). Analogously, the higher amount of available food images from social media is a consequence of the taking pictures behavior, which has been widely spread among consumers, and it is reflected by the user's obsession to take pictures before eating foods and meals. This behavior could allow researchers to explore the context of consumption of the users and their preferred food and beverage pairings by avoiding laboratory settings.

In general, this research could have significant implications for food and beverage researchers, sommeliers, and chefs who try to understand food pairing, as this is the base of food product development (Galmarini, 2020). In this study, although certain food and meal combinations may have been identified due to tradition or culturally influenced, some food-food or food-beverage combinations could be used to improve or develop new successful pairings.

In this research, images and texts were useful to explore food-food and food-beverage combinations. Social media analysis revealed that text users shared concise and specific information but were also less informative, while image information resulted more complete regarding a specific topic, such as beer-food pairing. Our results propose that images could be a good source of information when researchers investigate the gastronomic context of consumption. In general, any social media platform which involves images could act as a good source of information when studying food and meal pairing, as this research suggests that for consumers is easier to share experiences through photographs than using texts in social media.

5. Conclusions

This study has great potential for informing food researchers about the importance of social media as a tool for understanding food and meal pairing and consumer behavior, particularly regarding the context of consumption in the gastronomic field. In general, images resulted in a more informative source than text; also, texts mainly shared individual consumptions, while images shared more social moments. However, more research should be done to improve the efficiency of the data analysis, to facilitate and shorten the time invested in analyzing image by image. Integrating other disciplines specialized in images, such as arts, design, and semiotics, could improve the way we use images for consumer research. Additionally, the use and analysis of images bring a new range of possibilities to better understand not only food pairing but food choice and consumption.

Some limitations of this research are that images from the Twitter platform were not analyzed, only those from Instagram, to separate Twitter as a text (primary) based platform vs. Instagram as an image (primary) based platform. Special attention must be taken in the content analysis when exploring consumption behavior due that the displayed food and meals could not be frequently consumed by the users but only on special occasions.

Acknowledgments

Authors wish to thank CONACYT-MEXICO for the scholarship (2017-2020 period) granted to Araceli Arellano Covarrubias for her PhD at the Biotechnology Postgraduate Program at the Universidad Autónoma Metropolitana (520074/574751).

The author P. Varela would like to thank funding to the Norwegian Fund for Research Fees for Agricultural Products (FFL) through the project “FoodForFuture” (project number 314318).

Author contributions

Carlos Gómez-Corona: Conceptualisation, Supervision, and Writing-Reviewing and Editing.

Héctor, B. Escalona-Buendía: Conceptualisation, Supervision, and Writing-Reviewing and Editing.

Paula Varela: Conceptualisation, Supervision, and Writing-Reviewing and Editing.

Araceli Arellano-Covarrubias: Methodology, Formal Analysis, Investigation, and Writing-Original draft preparation

References

Abbar, S., Mejova, Y. & Weber, I. (2015). You tweet what you eat: Studying food consumption through Twitter. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems.*

Addinsoft (2019). XLSTAT statistical and data analysis solution. Long Island, NY, USA. https://www.xlstat.com.q

Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A.-L. (2011). Flavor network and the principles of food pairing. *Scientific Reports,* 1, 196. https://doi.org/10.1038/srep00196.

Alexa (2021). https://www.alexa.com Accessed 12 May 2021.

Arellano-Covarrubias, A., Gómez-Corona, C., Varela, P., & Escalona-Buendía, H.B. (2019). Connecting flavors in social media: A cross cultural study with beer pairing. *Food Research International,* 115, 303-310. https://doi.org/10.1016/j.foodres.2018.12.004.

Baker, S.A. & Walsh, M.J. (2018). "Good Morning Fitfam": Top posts, hashtags, and gender display on Instagram. *New Media and Society,* 20, 4553-4570. https://doi.org/10.1177/1461444818777514.

Bastian, S. E. P., Collins, C., & Jhonson, T. E. (2010). Understanding consumer preferences for Shiraz wine and Cheddar cheese pairings. *Food Quality and Preference,* 21, 668-678. https://doi.org/10.1016/j.foodqual.2010.02.002.

Casaló, L. V., Flavián, C., Ibáñez-Sánchez, S. (2018). Influencers on Instagram: Antecedents and consequences of opinion leadership. *Journal of Business Research*, 117, 510-519. https://doi.org/10.1016/j.jbusres.2018.07.005

Cerretani, L., Biasini, G., Bonoli-Carbognin, M. & Bendini, A. (2007). Harmony of virgin oil and food pairing: A methodological proposal. *Journal of Sensory Studies,* 22, 403-416. https://doi.org/10.1111/j.1745-459X.2007.00115.x.

Chen, G.M. (2011). Tweet this: A uses and gratifications perspective on how active Twitter use gratifies a need to connect with others. *Computers in Human Behavior,* 27, 755-762. https://doi.org/10.1016/j.chb.2010.10.023.

Chen, X., & Xining, Y. (2014). Does food environment influence food choices? A geographical analysis through "tweets". *Applied geography,* 51, 82-89. https://doi.org/10.1016/j.apgeog.2014.04.003.

Donadini, G., Fumi, M. D. & Lambri, M. (2012). The hedonic response to chocolate and beverage pairing: A preliminary study. *Food Research International,* 48, 703-711. https://doi.org/10.1016/j.foodres.2012.06.009.

Donadini, G., Fumi, M. D. & Lambri, M. (2013). A preliminary study investigating consumer preference for cheese and beer pairings. *Food Quality and Preference,* 30, 217-228. https://doi.org/10.1016/j.foodqual.2013.05.012

Donadini, G., Spigno, G., Fumi, M. D., Pastori, R. (2008). Evaluation of ideal everyday Italian food and beer pairings with regular consumers and food and beverages experts. *Journal of Institute of Brewing,* 114(4), 329-342. https://doi.org/10.1002/j.2050-0416.2008.tb00777.x.

Eschevins, A., Giboreau, A., Julien, P., Dacremont, C. (2019). From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer. *International Journal of Gastronomy and Food Science,* 17, 1-10. https://doi.org/10.1016/j.ijgfs.2019.100144.

Euromonitor International (2014). Alcoholic drinks in Mexico. *Retrieved from: Euromonitor Passport database.* London Euromonitor International.

Galiñanes, A., Delarue, J., Saulais, L. (2019). The pursuit of ecological validity through contextual methodologies. *Food Quality and Preference,* 73, 226-247. https://doi.org/10.1016/j.foodqual.2018.11.004

Galmarini, M. V. (2020). The role of sensory science in the evaluation of food pairing. *Current opinion in Food Science*, 33, 149-155. https://doi.org/10.1016/j.cofs.2020.05.003.

García-León, R.A. (2019). Twitter and Food well-being: Analysis of #SlowFood postings reflecting the food well-being of consumers. *Global Media Journal,* 16, 91-112. https://doi.org/10.29105/gmjmx16.30-5.

Gnambs, T. & Kaspar, K. (2015). Disclosure of sensitive behaviors across self-administered survey modes: a meta-analysis. *Behavior Research Methods,* 47,4, 1237-1259. https://doi.org/10.3758/s13428-014-0533-4.

Gómez-Corona, C., Escalona-Buendía, H. B., García, M., Chollet, S., & Valentin, D. (2016). Craft vs. industrial: Habits, attitudes and motivations towards beer consumption in Mexico. *Appetite,* 96, 358-367. https://doi.org/10.1016/j.appet.2015.10.002

Grupo Modelo, (2019). Available at: https://www.gmodelo.mx/es/marcas/corona-extra Accessed 08 April 2019

Harrington, R. J. (2005a). Defining gastronomic identity. *Journal of Culinary Science & Technology, 4, 2-3.* https://doi.org/10.1300/J385v04n02_10.

Harrington, R. J. & Hammond, R. (2005b). The direct effects of wine and cheese characteristics on perceived match. *Journal of Food Service Business Research,* 8,4, 37-54. https://doi.org/10.1300/J369v08n04_04.

Harrington, R. J. (2008). Food and wine pairing: A sensory experience. Hoboken, NJ: John Wiley & Sons, Inc.

Harrington, R. J., McCarthy, M. & Gozzi, M. (2010). Perceived match of wine and cheese and the impact of additional food elements: A preliminary study. *Journal of Foodservice Business Research,* 13,4, 311-330. https://doi.org/10.1080/15378020.2010.524541.

Harrington, R.J. & Seo, H-S (2015). The impact of liking of wine and food items on perceptions of wine-food pairing. *Journal of Foodservice Business Research,* 18,5, 489-501. https://doi.org/10.1080/15378020.2015.1093455.

Hennig- Thurau, Wiertz, and Feldhaus (2015). Does Twitter matter? The impact of microblogging word of mouth on consumer's adoption of new movies. *Journal of the Academy of Marketing Science, 43, 375-394.* https://doi.org/10.1007/s11747-014-0388-3

Hough, G., Wakeling, I., Mucci, A., Chambers IV, E., Méndez-Gallardo, I., Rangel-Alves, L., (2006). Number of consumers necessary for sensory acceptability tests. *Food Quality and Preference,* 17 (6), 522-526. https://doi.org/10.1016/j.foodqual.2005.07.002.

Hu, Y., Manikonda, L., & Kambhampati, S. (2014). What we Instagram: A first analysis of Instagram photo content and user types*. In Proceedings of the 8th International Conference on Weblogs and Social Media ICWSM 2014.* The AAAI Press.

Instagram (2019). *Help*. Available at: https://help.instagram.com/1215086795543252 Accessed 13 May 2021.

Instagram-press (2019). Available at: https://Instagram-press.com/our-story. Accessed 06 April 2019.

Java, A., Song, X., Finin, T., & Tseng, B. (2007). Why we Twitter: Understanding microblogging usage and communities. *Proceedings of the 9 WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis.*

Katz, E. (2009). Chili Pepper, from Mexico to Europe: Food, Imaginary and Cultural Identity. In Medina, F.X., Avila, R., De Garine I. (Eds.). *Food, imaginaries and cultural frontiers: essays in honour of Helen Macbeth.* (pp. 213-232).

King, M. & Cliff, M. (2005). Evaluation of ideal wine and cheese pairs using a deviation-from-ideal scale with food and wine experts. *Journal of Food Quality,* 28, 3, 245-256. https://doi.org/10.1111/j.1745-4557.2005.00033.x.

Klepper, M. (2011). Food pairing theory: A European fad. *Gastronomica*, 11(4), 55–58. https://doi.org/10.1525/gfc.2012.11.4.55

Lebart, L., Piron, M., & Morineau, A. (2006). *Statistique exploratoire multidimensionnelle. Visualisation et inférence en fouille de donnés.* Paris: Dunod.

Lee, E., Lee, J-A., Moon, JH., Sung, Y. (2015). Pictures speak louder than words: Motivations for using Instagram. *Cyberpsychology, behavior, and social networking,* 18,9, 552-556. https://doi.org/10.1089/cyber.2015.0157.

LO Monaco, G. & Bonetto, E. (2019). Social representation and culture in food studies. *Food Research International,* 115, 474-479. https://doi.org/10.1016/j.foodres.2018.10.029.

Mangold, W. G. & Fauld, D.J., (2009). Social media: The new hybrid element of the promotion mix. *Business Horizons,* 52, 357-365. https://doi.org/10.1016/j.bushor.2009.03.002.

Martínez, D. C., Hammond, R.K., Harrington, R.J. & Wiersma-Mosley, J. D. (2017). Young adult's and industry expert's subjective and objective knowledge of beer and food pairings. *Journal of Culinary Science & Technology,* 15,4, 285-305. https://doi.org/10.1080/15428052.2016.1256243.

Marwick, A. (2015). Instafame: Luxury selfies in the attention economy. *Public Culture,* 27, 137-160. https://doi.org/10.1215/08992363-2798379.

Meiselman, H. L. (2006). The role of context in food choice, food acceptance and food consumption. In R. Shepard & M. Raats. (Eds.) The Psychology of Food Choice. (pp. 179-199). London.

Meiselman, H. L. (2013). The future in sensory/consumer research: … evolving to a better science. *Food Quality and Preference,* 27, 208-214. https://doi.org/10.1016/j.foodqual.2012.03.002.

Paulsen, M. T., Rognsa, G. H., & Hersleth, M. (2015). Consumer perception of food-beverage pairings: The influence of unity in variety and balance. *International Journal of Food and Gastronomy Science,* 2, 83-92. https://doi.org/10.1016/j.ijgfs.2014.12.003.

Platania, M., & Spadoni, R. (2018). How people share information about food: Insights from tweets regarding two Italian regions. *International Journal on Food System Dynamics,* 9(2), 149-165. https://doi.org/10.22004/ag.econ.277712.

Powers, T., Advincula, D., Austin, M. S., Graiko, S. & Snyder, J. (2012). Digital and social media in the purchase decision Process. A special report from the Advertising Research Foundation. *Journal of Advertising Research,* 52 (4), 479-489. https://doi.org/10.2501/JAR-52-4-479-489.

Rozin, P. (1990). Getting to like the burn of chili pepper: Biological, psychological, and cultural perspectives. In Green, B. G., Mason, J. R., Kare, M. R. (Eds.). *Chemical senses. Volume 2: Irritation*. (pp. 231-269).

Scander, H., Monteagudo, C., Nilsen, B., Tellström, R., & Yngve, A. (2018). Food and beverage dinner combinations, patterns among Swedish adults. *International Journal of Gastronomy and Food Science,* 14, 20-26. https://doi.org/10.1016/j.ijgfs.2018.08.003.

Sester, C., Deroy, O., Sutan, A., Galia, F., Desmarchelier, J-F., Valentin, D. & Dacremont, C. (2013). "Having a drink in a bar": An immersive approach to explore the effects of context on drink choice. *Food Quality and Preference,* 28, 23-31. https://doi.org/10.1016/j.foodqual.2012.07.006.

Sheldon, P. & Bryant, K. (2016). Instagram: Motives for its use and relationship to narcissism and contextual age. *Computers in Human Behavior,* 58, 89-97. https://doi.org/10.1016/j.chb.2015.12.059.

Spence, C. (2018). Why is piquant/spicy food so popular? *International Journal of Gastronomy and Food Science,* 12, 16-21. https://doi.org/10.1016/j.ijgfs.2018.04.002.

Synthesio® social media listening platform. (2018) https://www.synthesio.com/ Accessed 18 July 2017.

Thomas, D.R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation,* 27 (2), 237-246. https://doi.org/10.1177/1098214005283748.

Thomé, K., Pirangy, A. & Ventura, J. (2017). Social interaction and beer consumption. *Journal of Food products Marketing,* 23 (2), 186-208. https://doi.org/10.1080/10454446.2017.1244797.

Traynor, M. P., Burke, R., O'Sullivan, M. G., Hannon, J. A. & Barry-Ryan, C. (2013). Sensory and chemical interactions of food pairings (basmati rice, bacon and extra virgin olive oil) with banana. *Food Research International, 54, 569-577. https://doi.org/10.1016/j.foodres.2013.07.050.*

Twitter (2021). *About.* Available at: https://about.twitter.com Accessed 13 May 2021.

Varshney, K.R., Varshney, L., Wang, J., & Myers, D. (2013). Flavor pairing in Medieval European cuisine: A study in cooking with dirty data. arXiv:1307.7982.

Vidal, L., Ares, G., Machín, L., & Jaeger, S. R. (2015). Using Twitter data for food-related consumer research: A case study on "what people say when tweeting about different eating situations. *Food Quality and Preference,* 45, 58-69. https://doi.org/10.1016/j.foodqual.2015.05.006.

Wearesocial, (2019). Available at: https://wearesocial.com/global-digital-report-2019 Accessed 06 April 2019.

Zhou, X. & Chen, L (2014). Event detection over Twitter social media streams. *The VLDB Journal,* 23,3, 381-400. https://doi.org/10.1007/s00778-013-0320-3.

Chapter 3. Food and beverage pairing through projective mapping

Outcomes of chapter 3:

- Oral presentation at the 15th SENSOMETRICS 2020 (online), Stavanger, Norway, 2020.
- Oral presentation at the SenseLatam (online), Brazil, 2020.
- A research article accepted to be published in Food Quality and Preference in 2021.

Arellano-Covarrubias, A., Varela, P., Escalona-Buendía, H.B. & Gómez-Corona, C. (2022). A food and beverage map: Exploring food-beverage pairing through projective mapping. *Food Quality and Preference,* 96, 104431. https://doi.org/10.1016/j.foodqual.2021.104431.

Food Quality and Preference 96 (2022) 104431

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A food and beverage map: Exploring food-beverage pairing through projective mapping

Araceli Arellano-Covarrubias[a,*], Paula Varela[b], Héctor B. Escalona-Buendía[a], Carlos Gómez-Corona[c]

[a] Sensory and Consumer Laboratory, Biotechnology Department, Universidad Autónoma Metropolitana, Av. San Rafael Atlixco No. 186, 09340 Mexico City, Mexico
[b] Nofima AS, P. O. Box 210, 1431 Ås, Norway
[c] XOC Estudio, Calderón de la Barca 359, 11559 Mexico City, Mexico

1. Introduction

1.1. Food pairing

Food pairing has been a popular topic amongst scientists, chefs, and researchers who try to find new successful food combinations and identify a pattern in how consumers pair food (Ahn et al., 2011). When studying food pairing, the "food pairing hypothesis" arises, which states that two ingredients that share chemical compounds are more likely to taste (and smell) good together (Simas et al., 2017; Kort et al., 2010; Tallab & Alrazgan, 2016). From a gastronomic approach, flavor pairing could be defined as flavors that, if paired, will produce an experience that is more appreciated than either of the two flavors alone (Møller, 2013). However, not all the flavor combinations are accepted worldwide, as they also heavily rely on culture (Arellano-Covarrubias et al., 2019).

Ahnert (2013) and Simas et al. (2017) studied the influence of culture and found that the rules that followed the food pairing are different between cultures. For example, Ahn et al. (2011) found that, in general, both Western and European Cuisine use ingredients that share similar flavor compounds, while East Asian Cuisine does the opposite. Following this last statement, Jain et al. (2015) found that different regional Indian Cuisines followed "negative" food pairing patterns: meaning that the higher the flavor sharing between two ingredients of Indian recipes, the lower the co-occurrence in that cuisine.

Besides the influence of culture in food pairing, other authors like Shepherd (2006) stated that the perception of flavor involves many sensory and motor systems. For instance, integral components of our eating experiences arise from all sub modalities of the somatosensory system: fine touch, creaminess, deep pressure (such as crunchiness), temperature, and pain (in the case of the burning sensation of chilis). In other words, an additional layer of olfactive or aromatic coincidence should be added to the act of pairing two or more food products. In this way, Eschevins et al. (2019) reported some pairing principles obtained from French sommeliers and beer experts that could be categorized in "conceptual" (geographical identity and context of consumption), "affective" (consumers' preferences and emotions), and "perceptual" (aroma, taste, texture); so, when venturing into food pairing research, several aspects should be considered.

Traditionally, food pairing research has widely focused on studies with wine and foods, such as cheese (Galmarini, 2020; Harrington & Seo, 2015; King & Cliff, 2005;). Some research studied how certain attributes of wine were affected by different food pairings. To take an example, hollandaise sauce (Nygren et al., 2001) and blue mold cheese (Nygren et al. 2002) were found to affect the perception of wine attributes such as a decrease in sour, bitter and toasted flavors, and an increase in butter flavor, in the case of hollandaise sauce research (Nygren et al., 2001); while buttery and woolly flavors and saltiness and sour taste decreased after tasting dry white wine (Nygren et al., 2002). With similar results, Madrigal-Galán and Heymann (2006) evaluated the effect of cheese before wine consumption and found that some wine attributes such as astringency, bell pepper, and oak flavor significantly decreased when red wine was evaluated after tasting the cheese. Therefore, the consumption of certain foods has been shown to impact the perception of the beverage, and vice versa; consuming a certain beverage is able to modify the perception of certain foods.

In a recent study, Kustos et al. (2020) found that appropriate food and wine pairings are positively correlated to liking, sensory complexity, and expected price to pay, and negatively with balance as a slight wine dominance was preferred. Bastian et al. (2010) evaluated wine and cheese matches where consumers rated whether the wine dominated the pair, or the cheese, or if the combination was an "ideal match". Authors

* Corresponding author.
E-mail addresses: araceli_ac50@hotmail.com (A. Arellano-Covarrubias), paula.varela.tomasco@nofima.com (P. Varela), hbeb@xanum.uam.mx (H.B. Escalona-Buendía), carlos.gomezcorona@gmail.com (C. Gómez-Corona).

https://doi.org/10.1016/j.foodqual.2021.104431
Received 29 April 2021; Received in revised form 5 October 2021; Accepted 7 October 2021
Available online 18 October 2021

found that wine domination of the cheese does not appear to drive the preference for wine and cheese pairs; it revealed that match perceptions were related to the overall liking for the wine alone. In this line, other studies (Donadini et al., 2012) explored the combination of several beverages with chocolate and found that the liking of a chocolate and beverage pair depended more on the liking for the beverage than for the chocolate or the level of the match of the two.

The evaluation of ideal food and beer pairings has also attracted researchers' attention (Donadini et al. 2013). Donadini et al. (2008) found that the suitability of a food-beer pair was positively correlated to the liking of the beer. In a similar study on craft beer and soup pairings, Paulsen et al. (2015) found that there is a significant effect of the beer type tasted and liking, as well as the dominance of either one of the components can reduce liking and perceived harmony, while the dominance of soup reduced the complexity of the pairing.

Regarding the food chemical interactions, some research has focused on different food pairings such as banana with basmati rice, bacon, and extra virgin olive oil (Traynor et al., 2013). The authors suggested that synergistic and/or antagonistic interactions between the volatile compounds in the evaluated foods influenced the ratings of the food pairings. Therefore, the hypothesis of successful food pairings based on the common shared volatiles was not verified. Contrarily King and Cliff (2005), found that, in general, stronger flavorful cheese is more likely to be a good match with a flavorful wine than milder flavorful cheeses. In the same way, Cichelli et al. (2020) studied the aromatic similarity as a congruency of the same flavor. The authors suggested a flavor congruency to enhance the oil-pairing harmony between olive oil with Italian vegetables, where harmony was maximized for olive oil with green and bitter flavor paired with very bitter or pungent vegetables. These last statements followed, to some degree, the food pairing hypothesis: "The more aromatic compounds two foods have in common, the better they taste together," which according to Klepper (2011), is particularly strong when two foods share aromas that make up their characteristic flavor.

However, restricting the food pairing to only the chemical similarity hypothesis would not necessarily lead to a successful food pairing, since all food combinations could have cultural, traditional, and physiological factors (Madrigal-Galán and Heymann, 2006), which makes the pairing more complicated than simply pairing foods that share common key compounds (Traynor et al., 2013). In addition, some of the reported findings are mainly based on professionals' perspectives and may not reflect how consumers feel (Madrigal-Galán and Heymann, 2006).

Some limitations of the study of "ideal pairings" in rather analytical studies have been the use of scales to indicate an ideal match where neither the food nor the wine dominates (King & Cliff, 2005; Bastian et al., 2010; Donadini et al., 2008; Donadini et al., 2013). Another limitation is that only a few products have been tested in the food pairing research and in western countries. A whole set of products and different cultures need to be explored to increase our understanding of ideal food-beverage pairings. In general, food pairing research opens a window of opportunity to apply different methodologies and approaches in the sensory and consumer research field due to the need to study the whole experience of food-beverage and food-food combinations (Galmarini, 2020).

1.2. Evaluation of food pairing

Since the study of food pairing became popular in consumer research, different methodologies have been applied to find successful food and beverage pairings as well as to understand the dynamics that explain why consumers pair certain foods with others. Regarding the hedonic side of food pairing, Donadini et al. (2013) explored the consumers' hedonic responses to cheese and beer pairings by using a natural environment of consumption. Consumers evaluate each cheese-beer pairing using a 9-point hedonic scale; additionally, a Just About Right scale was used to evaluate each pair for which flavor lingered the most (cheese or beer flavor). Likewise, Bastian et al. (2010) evaluated pairings of wine and cheese in a consumer test in a sensory lab. A Just About Right scale was used to test the "ideal match" of wine and cheese, and the liking of the pairing was rated on a 15 cm hedonic line scale. Harrington and Seo (2015) utilized a Likert-type 9-point scale to evaluate hedonic consumer' responses perceived from wine, food (dark chocolate and goat's cheese), and wine and food pairings.

A purely computational approach was taken by Ahn et al. (2011), who explored the impact of flavor compounds on combinations of ingredients by introducing a network-based approach. A bipartite network was built, which consists of two different types of nodes: ingredients used in recipes throughout the world and the flavor compounds that contribute to the flavor of each ingredient, where the natural occurrence of a compound in an ingredient was represented by a link (Ahnert, 2013). The bipartite network projection into the ingredients space represented the flavor network in which two nodes (ingredients) are connected if they share at least one flavor compound. In their study, Ahn et al. (2011) found that North American and Western European Cuisines exhibit a tendency towards recipes whose ingredients share flavor compounds, so in general, these cuisines confirmed the food pairing hypothesis in contrast to East Asian and Southern European cuisines.

Eschevins et al. (2018) tested the effect of the aromatic similarity on liking, harmony, homogeneity, complexity, and balance of food-beverage combinations by pairing a lemon soft drink with four dairy products prepared from "Fromage Blanc" (a kind of unsalted cottage cheese), aromatized with lemon, citrus + lemon, vanilla, and strawberry + lemon. In a second experiment, two beers were flavored with lemon and smoky aroma, and savory verrines were aromatized with the same aromas as those used for the beers. For each experiment, consumers tested the pairings using rating scales to evaluate liking, harmony, homogeneity, complexity, balance, and familiarity of pairings. In general, they found that pairings high in aromatic similarity showed increased ratings of harmony and homogeneity, and decreased complexity. Additionally, according to the food pairing hypothesis, the product pair with high aromatic similarity was preferred significantly over the pair the pair with low aromatic similarity.

With a different approach, Galmarini et al. (2017) evaluated the impact of wine on the perception of cheese, where the cheeses were dynamically characterized (with and without wine consumption) by using temporal dominance of sensations (TDS) coupled with a hedonic rating on a continuous scale. The researchers concluded that the wine had no impact on the liking for cheese, while the liking of wine was affected by cheese.

The reviewed literature only shows a brief compilation of the various methodologies and approaches that have been used in the research of food pairing where, except for the computational methodologies, only a few beverages and food items have been tested at once. The need for a methodology that could be repeated and standardized in the food pairing field (Galmarini, 2020) and the use of more consumer-oriented methods raise the interest in implementing new techniques that could lead to a better understanding of how consumers pair specific types of food and beverages.

1.3. Projective mapping

In the present research, projective mapping is presented as a tool for creating maps to better understand preferred food and beverage pairing amongst consumers. Projective mapping is a descriptive method that has been widely used in the sensory field as a method for fast profiling and measurement of consumers' perception (Berget et al., 2019), which provides a map that best reflects the perceived similarity of the evaluated products (Valentin et al., 2016).

The primary purpose of projective mapping is to obtain global similarity measurements between products from participants that, in general, are not trained assessors (Valentin et al., 2016). One of the main advantages of this methodology is the avoidance of panelist selection and training, which could impact the cost and time involved in maintaining well-trained panels; likewise, its relative ease of use compared with traditional descriptive models, such as quantitative descriptive analysis (QDA) (Savidan & Morris, 2015), has attracted researchers' attention. Moreover, the undirected nature of projective mapping as a projection technique, and the flexibility of the method, makes it suitable for diverse applications such as preference hedonic frame (Varela et al., 2017; Kim et al., 2019) or to study more complex sensory attributes, for example, the minerality of wines (Heymann et al., 2014).

Results from projective mapping can be analyzed with Principal Component Analysis (PCA) or Generalized Procrustes Analysis (GPA) (Gower, 1975; Tomic et al., 2015); additionally, Multiple Factor Analysis (MFA) (Brown et al., 2020) is also suitable because it considers the differences between assessors (Valentin et al., 2016). In the case of analyzing projective mapping with GPA, only two components can be extracted from the data (Tomic et al., 2015), while MFA results could provide more components (Berget et al., 2019).

According to Tomic et al. (2015), MFA and GPA typically find quite similar structures. Nestrud and Lawless (2008) previously reported that results from GPA and MFA were also very similar when the methods were applied to data from a single experiment of 13 citrus juices evaluated by experienced chefs and untrained consumers. In addition, GPA reduces individual differences between consumers' data by the processes of translation, rotation, reflection, and scaling of the configurations, and consequently, it preserves relative distances between the products in each configuration (Tomic et al., 2015). In this research, the distance and the variability of the consumers' food pairing data is essentially different; thus, adjusting and preserving the space are needed to find a consensus across all individuals. Therefore, in the case of food and beverage pairing, GPA seems to be statistically more suitable for analyzing consumers' information from projective mapping.

Traditionally, for projective mapping, the participants are asked to position products on a sheet of paper in such a way that the positions of the products reflect the products' similarity structure (Valentin et al., 2016). In this research, projective mapping was adapted, to where the positions of the products reflect food and beverage pairings according to consumer preferences: the shortest distance between two products represents a suitable food and beverage pairing. In contrast, the largest distance between two products represents a non-suitable food and beverage pairing.

In general, projective mapping has been used for assessing several food products. However, as Galmarini (2020) stated, food products are not usually consumed in an isolated manner; additionally, the author reported that the ingredient and food-beverage interactions are more complex than the study of shared volatiles alone, as food pairing theory states. These statements make it necessary to explore not only the aromatic compounds of food pairing but also the perception and preferences of food-food and food-beverage pairings. On these bases, the present research aims to explore young Mexican consumers' food and beverage pairing by using projective mapping as a consumer-oriented method to create maps that represent successful pairings.

2. Materials and methods

2.1. Food and beverages selection

According to a previous study (Arellano et al., 2019), beer was the most commonly explored alcoholic beverage due to it being the most consumed alcoholic beverage by Mexicans (Euromonitor International, 2014). However, since other beverages, such as wine and tequila, are also frequently consumed according to the above referenced sources, it was decided to explore not only beer but the most frequently consumed beverages among young Mexican consumers and their respective pairings from a set of frequently consumed food products.

The foods and beverages were selected from the information published in Arellano et al. (2019): several phrases, tweets, Instagram and Facebook posts and publications of consumers, related to both beer and food, were extracted from social media and mainstream (Corporate channels or Internet sites. e.g., general news, magazines, newspapers) data, for a one-year period, regardless of the time of day or the place the posts were published. Due to the nature of the extraction process and the privacy policies of some social media platforms, the gender and age of the users could not be registered exactly. From this study, sixty-four foods with a high frequency ofbeing paired with beer were extracted. Analogously, from the information from Instagram and Twitter, thirty-six foods that were popular among young Mexican users were also extracted. From the information, the most frequently paired foods in social media data were selected (Supplementary material 1).

A final list of thirty foods (Table 1) and six beverages were selected: soda, white and red wine, tequila, and blond and dark beer, due to the high popularity observed in the previous research, and growing (wine) or high (soda) consumption by Mexican consumers.

2.2. Participant's selection

One hundred Mexican participants were recruited from a Mexican University to perform this exploratory study. The recruitment process was carried out through advertisements, email messages, and personal communication. The inclusion criteria were to be above 18 years of age, and a regular alcoholic beverage consumer (at least once a month); however, consumer habits were not recorded. The gender and age of the participants were registered. Due to the recruitment process, the most expected age segment was 18–25 years old; therefore, the subsequent age categories were defined for intervals of 10 years.

2.3. Projective mapping

Several paper cards were designed for each food and beverage (Supplementary material 2) to guarantee that consumers evaluate all food and beverage items in the same way, as if they were testing real products (as usually done in face-to-face research). In addition, the use of images along with the product's name allowed the consumers' perception of the general sensory profile of foods and beverages to be investigated, and not only a specific flavor; furthermore, this approach allowed the test to be applied on different days without having variances in the food and beverages preparation. The use of images for research has been previously used for sorting tests with children (Varela & Salvador, 2014); also, Mielby et al. (2014) compared projective mapping and sorting to a generic descriptive analysis, using visually different pictures of fruit and vegetable mixes. In general, the use of visual stimuli instead of actual food products can minimize the time for sample preparation and the cost of the experiments (Mielby et al., 2014); in addition, in consumer studies, this approach has been increasing in recent years (Kildegaard et al., 2011; Mielby et al., 2012; Arce-Lopera et al., 2015, Varela & Salvador, 2014). In this research, images were used by designing several paper cards (3x4 cm) containing an image of the food/beverage and their respective names (Fig. 1).

The projective mapping was performed in a single session. Each participant was asked to first place the beverages on a sheet of paper (60x40cm) (Valentin et al., 2016). The cards' positions reflected similarities or differences between the beverages, so that the closer the beverages were positioned to each other, the greater their similarity.

Table 1
30 foods used in the projective mapping task that were extracted from social media data (Adapted from Arellano et al., 2019).

Avocado	Shrimp	Spices	Butter	Bread	Pineapple
Oats	Red meat	Hibiscus	Mango	Potato	Pizza
Salty snacks	Onion	Ginger	Apple	Cucumber	Chicken
Peanuts	Chili	Tomato	Berries	Fish	Cheese
Coffee	Chocolate	Lime	Orange	Pepper	Tortillas

Fig. 1. Food and beverages paper cards design used in the projective mapping, examples of red wine and berries. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Second, consumers were asked to position each food card on the same sheet of paper so that the cards' positions reflected better combinations between foods and beverages, while the closer a food was to a beverage or another food, the better the food-beverage or food-food pairing, according to their preferences. If some product seemed not to combine well with any food/beverage, the participants were asked to position it further from all the products. Participants could change the positions of the beverage and food cards as often as they needed.

To avoid errors in the measurements of the positions of the products on the sheet of paper, the participants were instructed to replicate the food and beverage maps on a computer screen, which was programmed in a similar way, and with similar measurements to those on the sheet of paper, by using the Fizz software® (Mielby et al., 2014). Any further change in the positions of the products on the computer screen was allowed in order to create a map of preferred food and beverage pairings. The duration of the task was about ten minutes. Fizz software® (version 2.51c 02) was used to convert the positions into coordinates, guaranteeing the unit measurements' homogeneity in the dimensions. Finally, the X and Y coordinates of each product for each participant were recorded.

2.4. Data analysis

The demographic information of the consumers, such as gender and age, were determined after the recruitment. Regarding the food and beverage pairing information, all food/beverage coordinates for each product and for each consumer were extracted from Fizz® and submitted to Generalized Procrustes Analysis (GPA). A permutation test for GPA (10000 permutations; significance 5%) was performed to test that the consensus map was above chance (Wakeling et al., 1992); and for the consensus coordinates, an Agglomerative Hierarchical Clustering (AHC) was performed (Euclidian distance; Ward's criterion) to find all food items that could be combined with each beverage. The variance within and inter clusters was calculated from 2 to 10 clusters to understand the differences across clusters, and better define the final number of clusters. Finally, to test the gender effect, a GPA for each gender was performed and RV coefficient was calculated between female and male GPA' coordinates, as has been previously done for projective mapping data (Orden et al., 2021; Tomic et al., 2015; Vidal et al., 2014). All statistical analyses were performed using XLSTAT software version 2012.5.02 (Addinsoft, 2019).

3. Results

Results from the participants' characteristics are shown in Table 2, the percentage of gender and age was calculated with the total sample of 100 participants. The study's goal was to achieve approximate balance in gender, resulting in 58% women and 42% men. Regarding the participants' age, more participants from 18 to 25 years old responded to the test. Because individual differences were beyond the scope of this study and due to the unbalanced age segments of consumers, no further analysis was performed on the age segments.

Table 2
Participant's demographic characteristics (N 100).

	Gender (Biological sex) Percentage (%)	**Age**(years) 18–25	26–35	36–45	46–55	Unknown
Women	58	42	13	0	0	3
Men	42	30	7	3	1	1
Total	100	72	20	3	1	4

3.1. Food-beverage pairing from projective mapping

Fig. 2 shows a product map from one consumer, where the proximity between beverages and foods represents the food and beverage pairings.

The food and beverage pairing data from projective mapping were analyzed with Generalized Procrustes Analysis (GPA). To explore the effect of gender, a GPA for each gender was performed and RV coefficient between female and male coordinates was calculated. The RV coefficient in the area of projective mapping has been the standard method when comparing matrices (Robert & Escoufier, 1976), and it has been used frequently for comparing data sets and consensus solutions (Tomic et al., 2015). The results of RV coefficients range from 0 to 1, with values closer to 1 indicating a greater degree of similarity between two configurations. Results of RV coefficient between women and men (0.694; *p-value* < 0.001) was relatively high, showing that both women's and men's coordinates were similar, and consequently, that their representation of the food and beverage pairings were comparable. Therefore, the interpretation will be focused only on the overall consensus GPA solution.

A PANOVA table (Supplementary material 3) was computed to evaluate the contribution of each Procrustes transformation to the reduction of the total variance in the GPA consensus. Results showed that a reduction of the variance was obtained from the three transformations, so in general, the individual differences between consumers were successfully reduced. Rotation (10.9, *p-value* < 0.0001) followed by translation (8.9, *p-value* < 0.0001) had the greatest effect on reducing variance, while scaling (1.8, *p-value* < 0.0001) had the lowest effect. According to Tomic et al. (2015), the differences in how consumers place the products could be due to two aspects. The first one depends on the differences in the perception of the products, while the second relies on the different ways of using the directions of the mapping sheet and is not related to the differences between products. In this sense, results of PANOVA showed that a large variance reduction of the non-sensory related individual differences was obtained through the Procrustes transformation.

A permutation test for GPA was performed to test whether the consensus map was real or a product of chance. The Rc statistic obtained from the permutation test represented the total variance explained by the consensus after the Procrustes transformations, with high Rc values indicating true consensus across individuals. The results showed an Rc statistic (0.153) greater than any of the Rc values from the 10 000 permutations (Mean Rc value: 0.065; Maximum Rc value: 0.07) and therefore, that the consensus configuration was not achieved by chance (100% percentile; level of significance of 5%) and the reduction of variance by Procrustes transformations was significant.

To understand the differences across clusters, the variance within and inter clusters was calculated from two to ten clusters. The results from the evolution of the clusters are shown in Table 3, as a function of

Fig. 2. Food and beverage map from projective mapping with images. Names of the products are shown in the original language (Spanish) of the test.

Table 3
Evolution of the within-classes and inter-classes variances. Values shown are percentages.

Number of clusters	2	3	4	5	6	7	8	9	10
Within-class variance	55.5	38.5	27.2	20.1	16.2	12.6	11.5	10.5	9.0
Inter-class variance	44.5	61.5	72.8	79.9	83.8	87.4	88.5	89.5	91.0
Total	100	100	100	100	100	100	100	100	100

the variance within-classes and inter-classes. As can be seen, from two to four clusters the decrease of the within variance is greater than those found from five to ten clusters, analogously, the inter-class variance increased more from two to four clusters than from five to ten clusters. Therefore, both variances show that 4 clusters are enough to consider as a cutting point in the AHC.

In general, projective mapping analyzed with GPA followed by AHC provided a suitable and easy interpretation of the food-beverage pairing from Mexican users. According to the consensus of the participants' preferences (consensus GPA map), the shortest distance between two products represents a better food and beverage pairing. To obtain data about which foods pair well with each beverage, an AHC was applied to the GPA consensus coordinates. The results clustered all food and beverages into four groups. The main finding is that each beverage could be clustered in an independent group along with different foods that people combined. The first group clustered both beers together, the second one grouped both wines, the third cluster contained Tequila and the last one contained soda. Fig. 3 represents the clusters obtained, where each group included all the foods that paired well with each beverage, according to consumer preferences.

Concerning the beverages, some of the map patterns were that dark and blond beer were clustered in the same group, along with some products such as salty snacks, pizza, peanuts, shrimp, red meat, and fish. In the case of wine, both red and white were clustered only along with cheese, bread, and berries; regarding Tequila, it was clustered with lime, which Mexican people usually combine with this beverage, also, butter, spices, pepper, and several fruits were grouped together. Soda was grouped with chicken, chili, potato, some vegetables, and tortillas, a popular product that Mexican people combine with their regular meals.

From the dendrogram obtained from AHC, additional information could be extracted. For instance, for each cluster, the food items closer to the beverages represented a better pairing than the food items further from the beverages. Fig. 4 shows the dendrogram obtained from the AHC.

Some of the most consensual pairings could be identified from Fig. 4. Potato, tortillas, chili, and chicken were closer to soda than cucumber, avocado or onion, representing a better food and beverage pairing in the cluster. In the case of beers, both dark and blond were closer to salty snacks, pizza, peanuts, and shrimp than fish and red meat. Regarding wine, both red and white were close to bread and cheese. Finally, Tequila was close to lime, and further from pepper and spices, which represented a better food and beverage pairing according to the consensus of consumer preferences.

4. Discussion

The present study aimed to explore Mexican consumers' food and beverage pairing using projective mapping as an innovative technique, analyzed by Generalized Procrustes Analysis (GPA). The analysis of projective mapping provided maps in which the proximity between products represents suitable food and beverage pairing according to the consumers' preferences.

The results from the PANOVA of the GPA showed that, in general, the individual differences between consumers were successfully reduced, and therefore, only the perception of the food and beverage products was assessed and not the individual differences across configurations. In other words, the reduction of the variance was lower when shrinking or stretching the individual map configurations until they were as similar as possible (scaling) to each other. On the other hand, when the configurations were rotated/reflected to agree with another map (rotation) or were moved to the middle of the mapping sheet (translation) (Tomic, et al., 2015), a higher reduction of the variance was obtained. These results suggest that consumers used different ways to position the products in terms of distances to represent the similarities and dissimilarities across the products and their pairings. This difference on the use of the distances across participants is better analyzed with the GPA,

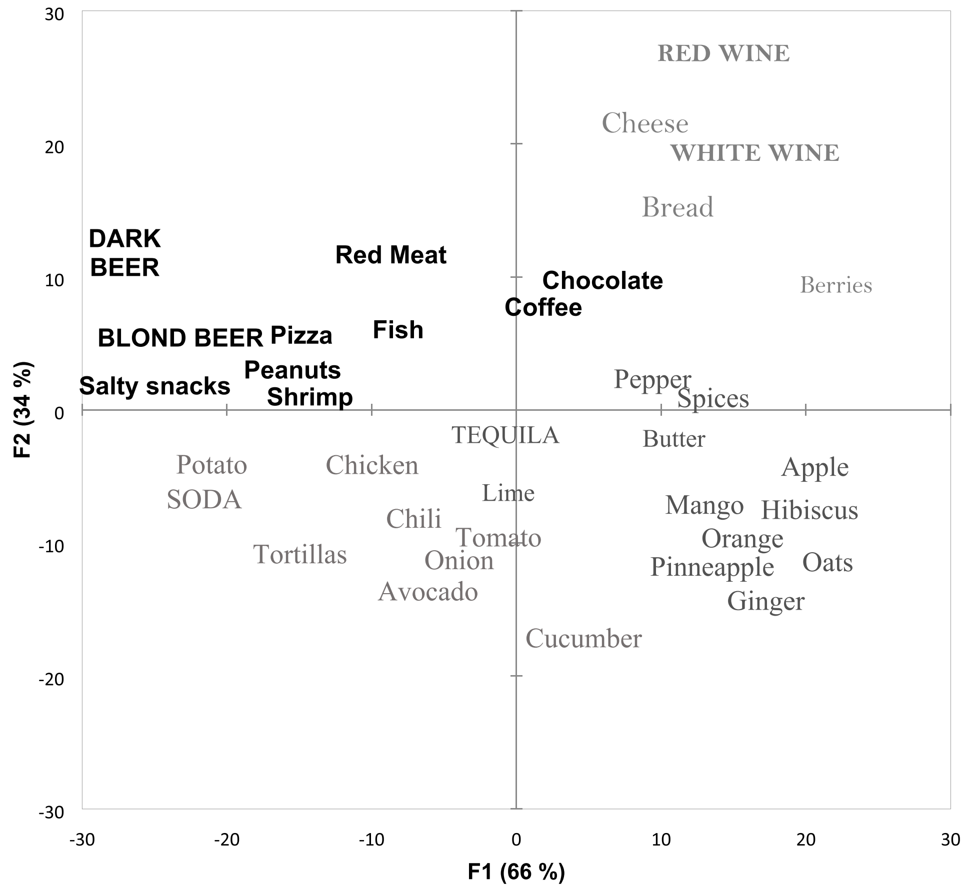


Fig. 3. Food-beverage pairing map for AHC of GPA. The hierarchical clustering is represented by similar gray color and font. AHC shows that beverages, and their respective food pairings, could be clustered into 4 groups.

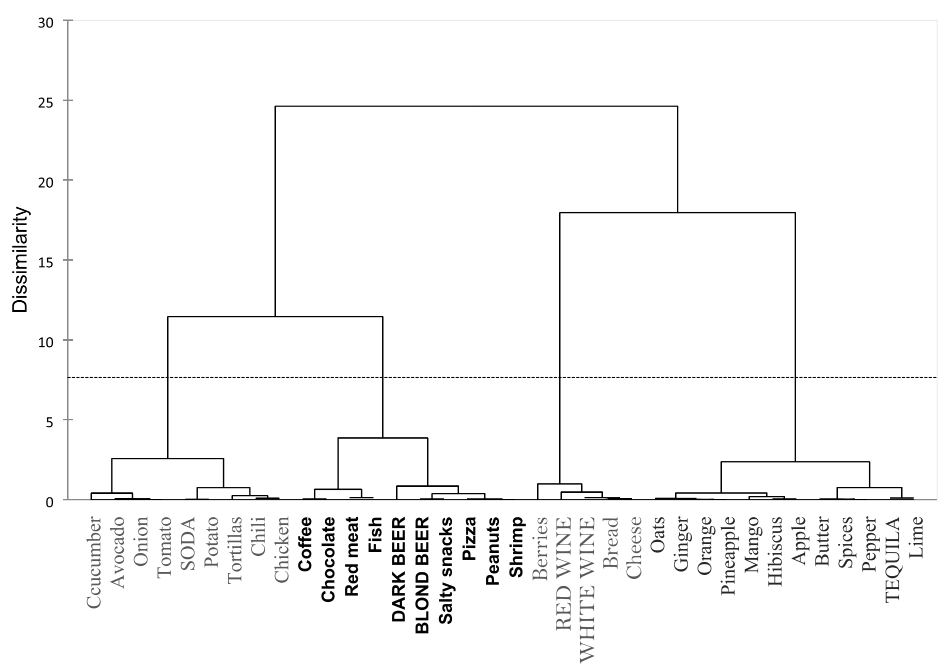


Fig. 4. Dendrogram from AHC of the GPA. The hierarchical clustering is represented by similar gray color and font.

compared to other methods such as MFA (Berget et al., 2019).

The result of the Rc statistic from the permutation test was 0.153, showing that the consensus was highly significant at 5% level. Tomic et al. (2015), in their research comparing simulated and real data sets from mapping experiments, reported that relatively high values (of 0.5 and 0.7) of R_c are obtained when the assessed products are "simpler," such as apple juices, while low values are reported for more complex products, such as coffee or wine. In the research published by Tomic et al. (2015), only one type of product was evaluated in each study, in contrast with this research, in which several complex products (wine, coffee, beer, and food items) were tested at once, which could have impacted the results of the R_c value.

In order to find which foods paired well with each beverage, an AHC was performed to the GPA consensus coordinates. As shown in Table 3, the inter-class variance had a higher increase until 4–5 clusters, while the within-class variance decreased by the same number of clusters and, therefore, provided enough evidence of differences between clusters, and similarities between the products in each cluster. As one of our objectives was to pair all foods with each beverage, 4 clusters were selected; otherwise, with 5 clusters, a set of food products would remain with no beverage to be paired with. The results split up all beverages into different clusters, reflecting that consumers generally considered the beverages as different.

Regarding the food pairings, several food items were clustered along with the beverages; for example, both beers (dark and blond) were clustered with salty snacks. In this sense, previous research has also reported that beer is regularly consumed with snack foods in Western Cultures (Pettigrew & Charters, 2006) and associated with purchasing fattier food items (Johansen et al., 2006). With similar findings, Donadini et al. (2008) found that pizza is a good pairing consumed with this beverage, which agrees with the AHC of the GPA, where pizza, shrimp, and peanuts, were also clustered along with beer in our study. In the case of wine, both red and white wines were clustered along with cheese and bread, which are widely reported as good combinations (King & Cliff, 2005; Bastian et al., 2010; Harrington & Seo, 2015).

The food and beverage pairings found in this research were not based on a flavor similarity approach but on consumer acceptance and perception which could generally rely on consumption habits in Mexico. For example, lime was clustered with Tequila, which is a highly accepted combination for younger Mexican consumers. Chili was clustered along with soda and several foods such as tortilla, chicken, tomato, and onion, which could reflect the Mexican behavior of adding chili to almost all food products in regular meals; as Rozin and Schiller (1980) stated since 1980, chili is a ubiquitous feature in the Mexican gastronomy, in other words, the chili pairing in Mexican consumers is more a matter of culture than flavor similarity.

In this study, popular foods and beverages among young Mexican consumers were tested; however, it is widely reported that cultural context influences consumer preferences and that beverage consumption with specific foods is a significant factor in distinguishing cuisines (Harrington et al., 2008). Therefore, since consumer culture is also a key component in food pairing and that little cross-cultural research can be found regarding food and flavor pairing (Galmarini, 2020), it could be interesting to assess the same set of products, as well as different popular foods, in other cultures, to evaluate the differences/similarities of acceptable pairings between consumer preferences. For example, with French consumers, who are known to have an extensive wine culture, the food and beverage pairings could have been different from those found in this research; analogously, the inclusion of other traditional beverages for Mexican consumers, such as Mezcal or Pulque, could have also yielded different results.

Regarding the data analysis, the RV coefficient was used to test the similarities between women's and men's GPA coordinates. Results of RV coefficient between women and men was high, representing similar configurations, and therefore, the perception of suitable food and beverage pairings was also similar between male and female consumers.

Previous research has reported that gender influences the habits and preferences of alcoholic consumption, e.g., Jimborean et al. (2021) found that Romanian male students drink alcoholic beverages to relax or socialize and, in general, preferred beer, while females consume alcohol for the beverage's taste or flavor and their favorite beverage was wine. In this sense, gender differences between young adults could play a role in the preferred alcoholic beverages (Martínez et al. 2017) and could impact the food and beverage pairing preferences of consumers. In an article on stereotypes and alcohol consumption, Rodrigues et al. (2020) talk about the gender differences across Mexican consumers, in terms of biological (sex) differences, and cultural gender differences. However, in this study, and as both beer and wine were tested, gender had no effect on food pairing.

This research showed the use of projective mapping for exploring food and beverage pairings, which produces maps that visually represent the consumers' preferences for pairing specific food products. With the aim of exploring food-pairing preferences of younger Mexican consumers, neither the share volatile compounds, from food-pairing theory, nor the concentration or detection threshold of the products were considered, only the consumer's perceptions of food and beverage combinations.

Some advantages can be highlighted in projective mapping as a methodological approach. In this research, no hedonic or rating scales were applied to evaluate consumer acceptance; the distance between food-food and food-beverages was used as a unit measurement for preferred food-pairing instead. Although the distance and the variability of the consumers' food and beverage pairing data could be essentially different, the adjustment and preservation of the space to find a consensus across all individuals was reached using GPA. The projective mapping approach allowed the evaluation and visualization of consumer preferences for a whole set of products simultaneously, in which a closer position between foods and beverages reflected a better combination of the items.

With the purpose of exploring consumers' preferences according to food consumption habits or traditional manner of consumption, the paper cards were designed only as a guide of isolated products. However, consumers were free to create a whole map of how they usually combined their foods and not how a product should be served. Also, consumers did not receive a description of what a "good combination" is, no definitions of an ideal match, balance, or harmony; nor were complementary or similarity matching in the products defined, which helped avoid biasing consumer perception of certain combinations. Additionally, by allowing consumers to position a "non-combinable" item further from all products, the methodology could explore if some food items were not suitable to be combined; however, this tendency was not observed in the maps obtained.

Although projective mapping was an effective and practical approach for exploring food-food and food-beverage pairings, the study had some limitations. Traditionally, a pairing usually starts with the food, and it is the beverage which accompanies the food. Here, however, we inverted the task as our research interest was exploring which foods would pair well with specific beverages. Additionally, in the projective mapping task, it was more manageable for consumers to start with visualizing the six beverages instead of the thirty food items. In further analysis, this aspect should be considered; however, it will depend on the study's objectives.

Some other factors, such as age, gender, and other demographic variables, should be considered in food pairing evaluation (Galmarini, 2020); however, in this research, no differences in food and beverage pairing could be found between female and male consumers. However, it could be a matter of the relatively low sample size, or that the stimuli used were too similar for the consumers, and therefore culture has a bigger effect than gender. In the case of the age of participants, it has been reported that it could impact consumers' habits and preferences, e.g., Garcia et al. (2013) reported that wine is the most frequently consumed drink among Spanish people over the age of 35, while consumers under 35 frequently consumed other drinks, such as beer. In this study, consumers were recruited only from a university in Mexico City from a narrow age range (18 to 25 years). Further research should include older consumers over 25 years old to test a potential age effect.

Another limitation to consider is the use of images instead of real food products. While several studies have used real food products to test food pairing, in this study, due to the high number of food and beverages tested, images were used only as a guide for consumers' perception homogeneity. So, this research provides an overview of what consumers perceived to be a suitable food and beverage pairing, based on their previous experiences. Further research must explore if the found pairings with images agree with real food products. In general, several aspects should be considered to follow this food pairing approach. Demographic variables, the use of real food instead of images, the evaluation of different food products, and the comparison of different cultures, could greatly interest the food pairing field.

In general, it was possible to relate a whole set of food items to a specific beverage or group of beverages. In some cases, such as wine, the pairings were previously reported for other cultures, while other pairings were specific to Mexican culture. Additionally, some food items were found to pair better than others. Overall, and according to the results, the exploration of food and beverage pairing through projective mapping, and analyzed through GPA, seems to be a suitable tool for exploring food and beverage pairing, and from which it was possible to obtain a complete food and beverage map that represented the better food combinations for consumers. However, the various aspects discussed above should be considered for further research exploring the proposed methodological approach.

5. Conclusions

This research showed that projective mapping was an effective technique to explore food-beverage pairings by producing maps representing how consumers combine specific foods and beverages. From these maps, it was possible to identify some patterns according to consumers' preferences, in which gender had no effect, meaning that consumers' culture was more important than gender. In general, GPA was a valuable tool to analyze and visualize consumers' food and beverage pairing data.

Some of the limitations that arise when analyzing the results are the relatively small sample size, the fact that all participants were young Mexican consumers, and that they come from a specific region in the center of Mexico. As previously suggested, culture could have a bigger impact than gender; the fact that consumers come from different cultures or from different age groups, can bring changes to flavor pairing, and has yet to be explored.

CRediT authorship contribution statement

Araceli Arellano-Covarrubias: Methodology, Formal analysis, Investigation, Writing – original draft. **Paula Varela:** Conceptualization, Supervision, Writing – review & editing. **Héctor B. Escalona-Buendía:** Conceptualization, Supervision, Writing – review & editing. **Carlos Gómez-Corona:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Authors wish to thank CONACYT-MEXICO for the scholarship (2017-2020 period) granted to Araceli Arellano Covarrubias for her PhD in the Biotechnology Postgraduate Program at the Universidad Autónoma Metropolitana (520074/574751).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2021.104431.

References

Addinsoft (2019). XLSTAT statistical and data analysis solution. Long Island, NY, USA. https://www.xlstat.com.q.

Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A.-L. (2011). Flavor network and the principles of food pairing. *Scientific Reports, 1*, 196. https://doi.org/10.1038/srep00196

Ahnert, S. E. (2013). Network analysis and data mining in food science: The emergence of computational gastronomy. *Flavour, 2*, 4. https://doi.org/10.1186/2044-7248-2-4

Arce-Lopera, C., Masuda, T., Kimura, A., Wada, Y., & Okajima, K. (2015). Model of vegetable freshness perception using luminance cues. *Food Quality and Preference., 40*, 279–286. https://doi.org/10.1016/j.foodqual.2014.06.010

Arellano-Covarrubias, A., Gómez-Corona, C., Varela, P., & Escalona-Buendía, H. B. (2019). Connecting flavors in social media: A cross cultural study with beer pairing. *Food Research International, 115*, 303–310. https://doi.org/10.1016/j.foodres.2018.12.004

Bastian, S. E. P., Collins, C., & Jhonson, T. E. (2010). Understanding consumer preferences for Shiraz wine and Cheddar cheese pairings. *Food Quality and Preference, 21*, 668–678. https://doi.org/10.1016/j.foodqual.2010.02.002

Berget, I., Varela, P., & Næs, T. (2019). Segmentation in projective mapping. *Food Quality and Preference, 71*, 8–20. https://doi.org/10.1016/j.foodqual.2018.05.007

Brown, A. L., Bakke, A. J., & Hopfer, H. (2020). Understanding American premium chocolate consumer perception of craft chocolate ad desirable product attributes using focus groups and projective mapping. *PLoS ONE, 15*, 11. https://doi.org/10.1371/journal.pone.0240177

Cichelli, A., Cerretani, L., Lecce, G. D., & Piochi, M. (2020). Exploring harmony in extra virgin olive oils and vegetables pairings. *Grasas y Aceites., 71*(2), 1–10. https://doi.org/10.3989/gya.0117191

Donadini, G., Fumi, M. D., & Lambri, M. (2012). The hedonic response to chocolate and beverage pairing: A preliminary study. *Food Research International., 48*(2), 703–711. https://doi.org/10.1016/j.foodres.2012.06.009

Donadini, G., Fumi, M. D., & Lambri, M. (2013). A preliminary study investigating consumer preference for cheese and beer pairings. *Food Quality and Preference, 30*, 217–228. https://doi.org/10.1016/j.foodqual.2013.05.012

Donadini, G., Spigno, G., Fumi, M. D., & Pastori, R. (2008). Evaluation of ideal everyday Italian food and beer pairings with regular consumers and food and beverages experts. *Journal of Institute of Brewing., 114*(4), 329–342. https://doi.org/10.1002/j.2050-0416.2008.tb00777.x

Eschevins, A., Giboreau, A., Allard, T., & Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference, 65*, 18–27. https://doi.org/10.1016/j.foodqual.2017.12.005

Eschevins, A., Giboreau, A., Julien, P., & Dacremont, C. (2019). From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer. *International Journal of Gastronomy and Food Science, 17*. https://doi.org/10.1016/j.ijgfs.2019.100144

Euromonitor International. (2014). Beer in Mexico. London: Euromonitor International. Retrieved from Euromonitor Passport database.

Galmarini, M. V. (2020). The role of sensory science in the evaluation of food pairing. *Current opinion in Food Science, 33*, 149–155. https://doi.org/10.1016/j.cofs.2020.05.003

Galmarini, M. V., Loiseau, A.-L., Debreyer, D., Visalli, M., & Schlich, P. (2017). Use of multi-intake Temporal Dominance of Sensations (TDS) to evaluate the influence of wine on cheese perception. *Journal of Food Science, 82*(11), 2669–2678. https://doi.org/10.1111/1750-3841.13500

Garcia, T., Barrena, R., & Ildefonso, Grande (2013). The wine Consumption preferences of young people: A Spanish case study. *International Journal of Wine Business Research, 25*(2), 94–107. https://doi.org/10.1108/IJWBR-2012-0007

Gower, J. (1975). Generalized Procrustes analysis. *Psychometrika, 40*(1), 33–51.

Harrington, R. J., Miszczak, D. C., & Ottenbacher, M. C. (2008). The impact of beer type, pizza spiciness and gender on match perceptions. PASOS. *Revista de Turismo y Patrimonio Cultural, 6*(2), 173–188. https://doi.org/10.25145/j.pasos.2008.06.014.

Harrington, R. J., & Seo, H.-S. (2015). The impact of liking of wine and food items on perceptions of wine-food pairing. *Journal of Foodservice Business Research, 18*(5), 489–501. https://doi.org/10.1080/15378020.2015.1093455

Heymann, H., Hopfer, H., & Bershaw, D. (2014). An exploration of the perception of minerality in white wines by projective mapping and descriptive analysis. *Journal of Sensory Studies, 29*(1), 1–13. https://doi.org/10.1111/joss.12076

Jain, A., N. K., R. & Bagler, G. (2015). Analysis of food pairing in regional cuisines of India. PLoS ONE, 10,10. Doi: 10.1371/journal.pone.0139539.

Jimborean, M.A., Salanță, L.C., Trusek, A., Pop, C.R., Tofană, M., Mudura, E., Coldea, T. E., Farcaș, A., Ilieș, M., Pașca, S., Uifălean (2021). A. Drinking Behavior, Taste Preferences and Special Beer Perception among Romanian University Students: A Qualitative Assessment Research. International Journal of Environmental Research and Public Health, 18:6 3307. Doi: 10.3390/ijerph18063307.

Johansen, D., Friis, K., Skovenborg, E., & Grønbæk, M. (2006). Food buying habits of people who buy wine or beer: Cross sectional study. *BMJ British Medical Journal, 332* (7540), 519–521. https://doi.org/10.1136/bmj.38694.568981.80

Kildegaard, H., Olsen, A., Gabrielsen, G., Møller, P., & Thybo, A. K. (2011). A method to measure the effect of food appearance factors on children's visual preferences. *Food Quality and Preference, 22*, 763–771. https://doi.org/10.1016/j.foodqual.2011.06.009

King, M., & Cliff, M. (2005). Evaluation of ideal wine and cheese pairs using a deviation-from-ideal scale with food and wine experts. *Journal of Food Quality, 28*, 245–256. https://doi.org/10.1111/j.1745-4557.2005.00033.x

Kim, M.-R., Kim, K.-P., & Chung, S.-J. (2019). Utilizing hedonic frame for projective mapping: A case study with Korean fermented soybean paste soup. *Food Quality and Preference, 71*, 279–285. https://doi.org/10.1016/j.foodqual.2018.07.014

Klepper, M. (2011). Food pairing theory: A European fad. *Gastronomica, 11*(4), 55–58. https://doi.org/10.1525/gfc.2012.11.4.55

Kort, M., Nijssen, B., van Ingen-Visscher, K., & Donders, J. (2010). Food pairing from the perspective of the "Volatile compounds in food" database. *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium, Interlaken, Switzerland, 589-592.*.

Kustos, M., Heymann, H., Jeffery, D. W., Goodman, S., & Bastian, S. E. P. (2020). Intertwined: What makes food and wine pairings appropriate? *Food Research International., 136*, Article 109463. https://doi.org/10.1016/j.foodres.2020.109463

Madrigal-Galán, B., & Heymann, H. (2006). Sensory effects of consuming cheese prior to evaluating red wine flavor. *American Journal of Enology and Viticulture, 57*(1), 12–22.

Martínez, D. C., Hammond, R. K., Harrington, R. J., & Wiersma-Mosley, J. D. (2017). Young adult's and industry expert's subjective and objective knowledge of beer and food pairings. *Journal of Culinary Science & Technology, 15*(4), 285–305. https://doi.org/10.1080/15428052.2016.1256243

Mielby, L. H., Hopfer, H., Jensen, S., Thybo, A. K., & Heymann, H. (2014). Comparison of descriptive analysis, projective mapping and sorting performed on pictures of fruit and vegetable mixes. *Food Quality and Preference, 35*, 86–94. https://doi.org/10.1016/j.foodqual.2014.02.006

Mielby, L. H., Kildegaard, H., Gabrielsen, G., Edelenbos, M., & Thybo, A. K. (2012). Adolescent and adult visual preferences for pictures of fruit and vegetable mixes-Effect of complexity. *Food Quality and Preference, 26*, 188–195. https://doi.org/10.1016/j.foodqual.2012.04.014

Møller, P. (2013). Gastrophysics in the brain and body. *Flavour, 2*, 8. https://doi.org/10.1186/2044-7248-2-8

Nestrud, M., & Lawless, H. T. (2008). Perceptual mapping of citrus juices using projective mapping and profiling data from culinary professionals and consumers. *Food Quality and Preference, 19*(4), 431–438. https://doi.org/10.1016/j.foodqual.2008.01.001

Nygren, I. T., Gustafsson, I.-B., Haglund, Å., Johansson, L., & Noble, A. C. (2001). Flavor changes produced by wine and food interactions: Chardonnay wine and hollandaise sauce. *Journal of Sensory Studies, 16*(5), 461–470. https://doi.org/10.1111/j.1745-459X.2001.tb00313.x

Nygren, I. T., Gustafsson, I.-B., & Johansson, L. (2002). Perceived flavour changes in white wine after tasting blue mould cheese. *Food Service Technology, 2*(4), 163–171. https://doi.org/10.1046/j.1471-5740.2002.00048.x

Orden, D., Fernández-Fernández, E., Tejedor-Romero, M., & Martínez-Moraian, A. (2021). Geometric and statistical techniques for projective mapping of chocolate chip cookies with a large number of consumers. *Food Quality and Preference, 87*, Article 104068.

Paulsen, M. T., Rognsa, G. H., & Hersleth, M. (2015). Consumer perception of food-beverage pairings: The influence of unity in variety and balance. *International Journal of Gastronomy and Food Science., 2*(2), 83–92. https://doi.org/10.1016/j.ijgfs.2014.12.003

Pettigrew, S., & Charters, S. (2006). Consumers' expectations of food and alcohol pairing. *British Food Journal, 108*(3), 169–180. https://doi.org/10.1108/00070700610650990

Robert, P., & Escoufier, Y. (1976). A unifying tool for linear multivariate statistical methods: The RV-coefficient. *Applied Statistics, 25*, 257–265. http://www.jstor.org/stable/2347233.

Rodrigues, H., Goméz-Corona, C., & Valentin, D. (2020). Femininities & masculinities: Sex, gender, and stereotypes in food studies. *Current Opinion in Food Science, 33*, 156–164.

Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion, 4*, 77–101. https://doi.org/10.1007/BF00995932

Savidan, C. H., & Morris, C. (2015). Panelists' performance and strategies in paper-based and computer-based projective mapping. *Journal of Sensory Studies., 30*(2), 145–155. https://doi.org/10.1111/joss.12146

Shepherd, G. M. (2006). Smell images and the flavour system in the human brain. *Nature, 444*, 316–321.

Simas, T., Ficek, M., Diaz-Guilera, A., Obrador, P., & Rodriguez, P. R. (2017). Food bridging: A new network construction to unveil the principles of cooking. *Frontiers in ICT, 4*, 14. https://doi.org/10.3389/fict.2017.00014

Tallab, S. T., & Alrazgan, M. S. (2016). Exploring the food pairing hypothesis in Arab cuisine: A study in computational gastronomy. *Procedia Computer Science, 82*, 135–137. https://doi.org/10.1016/j.procs.2016.04.020

Tomic, O., Berget, T., & Næs, T. (2015). A comparison of generalised Procrustes analysis and multiple factor analysis for projective mapping. *Food Quality and Preference, 43*, 34–46. https://doi.org/10.1016/j.foodqual.2015.02.004

Traynor, M. P., Burke, R., O'Sullivan, M. G., Hannon, J. A., & Barry-Ryan, C. (2013). Sensory and chemical interactions of food pairings (basmati rice, bacon and extra virgin olive oil) with banana. *Food Research International, 54*, 569–577. https://doi.org/10.1016/j.foodres.2013.07.050

Valentin, D., Cholet, S., Nestrud, M., & Abdi, H. (2016). Projective mapping and sorting task. In J. Hort, S. Kemp, & T. Hollowood (Eds.), *Descriptive Analysis in Sensory Evaluation*. London: Wiley-Blackwell.

Varela, P., Berget, I., Hersleth, M., Carlehög, M., Asioli, D., & Næs, T. (2017). Projective mapping based on choice or preference: An affective approach to projective mapping. *Food Research International, 100*, 241–251. https://doi.org/10.1016/j.foodres.2017.08.049

Varela, P., & Salvador, A. (2014). Structured sorting using pictures as a way to study nutritional and hedonic perception in children. *Food Quality and Preference, 37*, 27–34. https://doi.org/10.1016/j.foodqual.2014.04.009

Vidal, L., Cadena, R. S., Antúnez, L., Giménez, A., Varela, P., & Ares, G. (2014). Stability of sample configurations from projective mapping: How many consumers are necessary? *Food Quality and Preference, 34*, 79–87.

Wakeling, I. N., Raats, M. M., & MacFie, H. J. H. (1992). A new significance test for consensus in generalized procrustes analysis. *Journal of Sensory Studies, 7*, 91–96.

Chapter 4. Cross-cultural application of projective mapping to study food and beverage pairing

Outcome of chapter 4:

A draft manuscript to be completed and submitted to Food Quality and Preference as a first option in 2022

CULTURAL ASPECTS OF FOOD PAIRING: A CASE STUDY WITH NORWEGIAN AND MEXICAN CONSUMERS

Araceli Arellano-Covarrubias, Paula Varela, Héctor B. Escalona-Buendía, Carlos Gómez-Corona

ABSTRACT

Culture is a driver of food choices and, therefore, it could also influence the selection of food and beverage pairings. Food pairing has been studied from different approaches, in which food researchers intend to find successful food and beverage combinations; however, little cross-cultural research has been published. In this research, food pairing was explored using projective mapping to create maps of preferred food and beverage combinations between alcoholic beverage participants of Mexico and Norway. Thirty foods and six beverages were selected based on previous studies. Projective mapping was applied in each country through an online survey, in which participants were asked to position each food item close to a food or beverage that represented a good combination, according to their own perception or preferences. For each country, the positions of each food and beverage item were translated to coordinates and analyzed through Generalized Procrustes Analysis (GPA) followed by Agglomerative Hierarchical Clustering (AHC). Additionally, the coordinates of the two factors from each GPA were used to calculate an RV coefficient analysis to test the similarities between the coordinates. Projective mapping provided maps of food and beverage pairings for each country in which the proximity between food-food or food-beverages represented a good combination according to consumer perception, expectations, or preferences. Results from the comparison of perceptual spaces from Mexico and Norway via RV coefficient suggested that perception of food-beverage pairings in those countries were different; nevertheless, some similarities were found between the countries. AHC was applied for each country to group foods that could be paired with each beverage. In general, food and beverage pairing was effectively explored using projective mapping, from which several differences and similarities between different cultures could be uncovered.

Keywords: Food-beverage pairing, Projective mapping, Cross-cultural, Mexico, Norway.

1. Introduction

The influence of culture in food studies has seen prolific growth within sociologists and anthropologists over the past century (Harrington, 2005), from which the food (and beverages) we consume in daily life is a relevant starting point for this type of research (Holm et al., 2019). Food and beverages are two of the most basic needs for human beings; however, society is in constant evolution and, therefore, food and beverage show a strong cultural influence, being able to describe significant differences among people (Silva et al., 2014).

During the last decade, the interest in food pairing has been in continuous growth. Chefs, consumers, computer scientists, and sensory scientists have been interested in understanding, even predicting, good food and beverage combinations (Spence, 2020). In general, there are diverse reasons that lead to good food and beverage combinations. Food pairing theory reduce a good pairing to its chemical composition; however, it has been stated that volatile compatibility is not the only aspect that influences a good pairing (Galmarini, 2020).

Although the popular literature has recommended suitable pairings to try, as well as some bad combinations that should be avoided, the basis on such recommendations are unclear. Worldwide cuisines are constantly evolving due to traditions, changes in preferences, product availability, or current fashions (Harrington, 2005). Even more, it is known that some factors, such as age, gender, familiarity are essential when explaining preference and, therefore, should be considered when venturing in the food and beverage pairing field (Galmarini, 2020)

1.1 Food pairing

The evolution of humans and their relationship with foods has increased mainly due to technological and socioeconomic factors (Rojas-Rivas et al., 2020). Traditionally, food pairing was considered only at a level of psychology/perception. However, an increased interest in predicting perceptual similarity/matching based on physicochemical similarity of the component stimuli has arisen (Spence, 2020), which was started by the Food paring theory. This theory states that ingredients sharing flavor compounds are more likely to taste well together than ingredients that do not (Ahn et al., 2011) and that this effect is enhanced when two foods are sharing aromas that make up their characteristic flavor (Klepper, 2011). Some of the flavor combinations that supported the food pairing hypothesis include the pairings of chocolate and caviar (Ahn et al., 2011) which contain amines, and pork liver and jasmine which share the volatile compound indole (Spence, 2020). However, as Galmarini (2020) stated, the volatile composition alone does not make a good pairing, as other food components could impact food perception.

The amount and type of proteins, carbohydrates, and lipids that a food has, and therefore, some characteristics of food such as texture, temperature, sound, and trigeminal sensations, could contribute to the perception of food pairing (Varshney et al., 2013). In addition, foods and beverages are usually consumed in different combinations, which could also influence the perception of the pairings (Köster, 2003). Therefore, the study of food and beverage pairing should not be based only on the intrinsic characteristics of food and ingredients but also on the arrangement of ingredients in a recipe, the combination of food-food and food-beverages, and the preparation of a whole meal (Galmarini, 2020).

In general, food pairings could be defined as foods or food and a beverage, that when consumed together, may present different (and acceptable) sensory properties than when consumed alone (Lahne, 2018). Traditionally, food pairing research has been focused on the combination of foods with wine (Galmarini, 2020; Harrington & Seo, 2015; Bastian et al., 2010; King & Cliff, 2005); however, during recent years, several studies have extended their interest into the study of all kinds of food and drinks, such as chocolate paired with beverages (Donadini et al., 2012), or beer with different foods (Donadini et al., 2008; Donadini et al., 2013; Martínez et al., 2017).

In general, the focus on parings of foods and beverages in the sensory and consumer science has largely been ignored (Lahne, 2018). According to Galmarini (2020), the study of the sensory experience of food-beverage or food-food combinations is needed because foodstuffs are not usually consumed in an isolated manner but as a whole meal. In addition, it has been stated that the components, texture, and flavor profiles in both wine and beer could be impacted by culture, history, and ethnic diversity (Harrington, 2005). It is highly relevant to consider that culture determines the exposure to foods and food pairings, and therefore, the preference for them.

1.2 Cross-cultural studies in the food pairing field

Human food choice is determined by many factors. Most of them fall in psychology (individual experience) and either direct or indirect cultural influences. (Rozin, 2002). For instance, over a thousand years, people have been preparing food, and as well as other skills, the knowledge associated with cooking has traditionally been passed on between mother or father and child (Christensen & Stuart, 2019). Consequently, our food choices are based on learning and cultural transmission (Rozin, 2005).

In humans, as in other species, food choice is predominantly a learned behavior that is dynamic and subject to continuous change, where the liking of foods depends on eating situations and the previous exposure to a product (Köster & Mojet, 2006). In this sense, cuisines and food culture are influenced by aspects beyond only the nutritional component of foodstuffs but also by the symbolic identity attached to foods (Sánchez-Cañizares &López-Guzmán, 2012). Therefore, the study of food and beverage pairing constitutes a more complex task than only the association between two liked products (Eschevins et al., 2018).

Tradition is a key component in food pairing (Galmarini, 2020) and, since food (and beverage) preferences are influenced by several cultural aspects, including social needs and advances in technology (Rozin, 2002), cross-cultural studies are of high relevance for understanding the food preferences of consumers living in different cultures (Rozin & Schiller, 1980). For instance, some food and beverage combinations are accepted in some cultures and rejected in others, as many conventional pairings have emerged from cultural/geographical matches (Spence, 2020); furthermore, the diversity of the culinary practices between countries leads to different successful food combinations.

The rules that follow food pairing have been studied in different cultures. Ahn et al. (2011) found that Western and European cuisines follow the food pairing hypothesis where these cuisines use ingredients that share similar flavor compounds, while East cuisine do not.

Analogously, different regional Indian cuisines did not follow the food pairing hypothesis (Jain et al., 2015).

Kim et al. (2018) evaluated the acceptance levels of hot sauces applied to five food items (pizza, cream soup, grilled chicken wings, rice noodle soup) among consumers from different culinary cultures, such as South Korea, the US, and Denmark. Authors found that consumers' perception of hot and spicy flavor showed that culinary exposure, usage, and reasons for liking the hot sauces varied among the cultures. In the same line, the authors found that particular sauces paired better with specific food items and that these pairings were also culture-dependent.

Despite food pairing has been studied through the last years, and cultural influence is of great relevance to the food and beverage pairing field, little cross-cultural research can be found. Moreover, the study of food pairing requires consumer-oriented methods since consumers are the ones who decide which combinations are accepted or rejected. In the present research, projective mapping was applied to create food and beverage maps for exploring food pairing from different cultures.

Specifically, Norway and Mexico were selected as cases of study. Mexico is known to have a traditional cuisine included within the List of Intangible Cultural Heritage of UNESCO (Rojas-Rivas, 2020), from which some ingredients have prevailed since pre-Columbian times (Spence, 2017). In the case of Norway, Holm et al. (2019), in their analysis of how the food has changed in four Nordic countries during a 15-year period (from 1997 to 2012), found that the Nordic everyday cuisine includes many elements that could be regarded as quite traditional for that culture.

In general, Nordic countries do not seem to have absorbed global patterns seen in other countries. Analogously, many of the mentioned foods found by Rojas-Rivas et al. (2020) were considered 'traditional' representative of the cultural and gastronomic heritage of the different regions in Mexico. In this way, the food culture of both Mexico and Norway has been shown to be consistent (to their own culture) over the years, despite that in modern times, food cultures fade into a more globalized homogenizing trend highly influenced by global food manufacturers (Holm et al., 2019). These last statements serve as the basis for a search into the food culture of Norway and Mexico, which could be achieved by exploring the food and beverage pairing according to consumer perceptions.

2. Materials & methods

2.1 Food and beverages selection

Thirty foods (Table 1) and six popular beverages (soda, white and red wine, tequila, and blond and dark beer) were selected from Arellano et al. (2022).

Table 1

Foods extracted from Arellano et al. (2022)

Avocado	Shrimp	Spices	Butter	Bread	Pineapple
Oats	Red meat	Hibiscus	Mango	Potato	Pizza
Salty snacks	Onion	Ginger	Apple	Cucumber	Chicken
Peanut	Chili	Tomato	Berries	Fish	Cheese
Coffee	Chocolate	Lime	Orange	Pepper	Tortillas

2.2 Demographic and consumption information

One hundred participants for both Norway and Mexico, who consumed alcoholic beverages at least once per month, performed the test through an online survey. The recruitment process was carried out through email messages and personal communication. Demographic information, such as age and gender, was recorded. Additionally, the frequency of consumption and the most frequently consumed alcoholic beverages were also registered.

2.3 Projective mapping

An online projective mapping was programmed using the software Fizz® (for Mexico) and EyeQuestion® (for Norway). For each country, the applied survey was translated to the native language of each country. The projective mapping methodology was performed by participants in a single session where each beverage and food were identified through a three-letter code (for Mexico) and a complete name (for Norway). For example, the beverage tequila was identified with "TEQ" for Mexico, while in Norway the complete name of the product "Tequila" was used. Each participant was asked first to place the beverage codes/names on the computer screen, programed with proportional measurements suggested by Valentin et al. (2016) (60x40cm). The beverages' positions reflected similarities or differences between them so that the closer the beverages were positioned to each other, the more similar they were.

Second, participants were asked to position each food code/name on the same screen so that the food' positions reflected better combinations between foods and beverages: the closer a food to a beverage or another food, the better food-beverage or food-food pairing according to consumer' preferences. If a product seemed not to combine well with any food/beverage, participants were asked to position it far from the rest. Participants could change the beverage and food codes/names' positions the times they needed in order to create a map of preferred food and beverage pairings. Both Fizz software® (version 2.51 c 02) and EyeQuestion® (Logic 8BV, The Netherlands) converted the food and beverage positions into coordinates, warranting the homogeneity of the unit measurements in the dimensions.

2.4 Data analysis

The percentage of occurrence for gender, age, frequency of consumption, and most consumed alcoholic beverages was calculated for participants' information. Differences between participants of Mexico and Norway were assessed using chi-square tests, followed by multiple z-proportions tests.

For each country, all food/beverage coordinates for each participant were analyzed through Generalized Procrustes Analysis (GPA) followed by Agglomerative Hierarchical Clustering (AHC) (Euclidian distance; Ward's criterion), to find all food items that could be combined with each beverage. The two factors of each GPA were used to calculate an RV coefficient to test the proximity between the coordinates. All statistical analyses were performed with XLSTAT software version 2012.5.02 (Addinsoft, 2019).

3. Results

The results of the present research are divided into two sections. The first one shows the demographic and consumption information collected from participants, while the second one provides an insight into the patterns of food pairing found for each country.

3.1 Demographic and consumption information

Percentage of occurrence for gender and age were calculated. For each gender category, multiple z-proportion tests were performed between age categories. Table 2 shows the obtained information for each country.

Table 2

Gender and age information for each country

Gender	Age (years)	Mexico (%)	Norway (%)	P-value
Women ($\chi^2_{(4,200)}$=49.328, *p<0.0001*)	**18-25**	8	**39**	<0.0001
	26-35	**39**	8	<0.0001
	36-45	11	9	0.482
	46-55	2	9	0.095
	56+	2	9	0.095
	Total	62	74	0.067
Men ($\chi^2_{(4,200)}$ =15.255, *p=0.004*)	18-25	3	4	0.633
	26-35	**22**	7	0.014
	36-45	10	4	0.410
	46-55	1	5	0.105
	56+	1	**6**	0.049
	Total	37	26	0.125
Nonbinary	18-25	0	0	---
	26-35	1	0	---
	36-45	0	0	---
	46-55	0	0	---
	56+	0	0	---
	Total	1	0	---

Results of chi square tests are shown for each gender category. For z-proportions test results, bold age categories indicate those that were significantly different between countries, while bold numbers indicate the higher percentage of occurrence for the respective country. Nonbinary category was not submitted to analysis.

For both countries, more women than men responded to the test. The chi-square test for global gender ($\chi^2_{(2,200)}$ =3.979, *p=0.137*) showed no significant difference between participants' characteristics. In the case of Mexico, more participants (men and women) from 26 to 35 years old, and for Norway, more women participants from 18 to 25 years old than other age classifications responded to the test.

The frequency of consumption of alcoholic beverages showed that 53% of Mexican participants drink alcoholic beverages daily and from one to three times per week compared to the 69% of Norwegian participants who consume alcoholic beverages in the same time-lapse. For comparison purposes, an additional z-proportion test was performed by comparing the percentages of the more frequent consumption times (daily, 2-3 times per week, and once a week). Results showed a significant difference (*p=0.027*) between countries, being Norwegian participants who drink more frequently in a week lapse than Mexican participants.

Table 3 shows the most frequently consumed alcoholic beverages between the participants of each country.

Table 3

Frequency of occurrence of the commonly consumed alcoholic beverages for each country

		Mexico	Norway	P-value
Alcoholic beverages ($\chi^2_{(4,200)}$=114.731, *p<0.0001*)	**Blond beer**	51	**75**	0.001
	Dark beer	**79**	16	<0.0001
	White wine	15	**47**	<0.0001
	Red wine	50	**65**	0.043
	Whisky	**31**	5	<0.0001
	Vodka	24	15	0.151
	Tequila	**27**	1	<0.0001
	Rum	**17**	4	0.005
	Brandy	9	2	0.060
	Other	21	14	0.262

Result of chi square test is shown for the frequent consumed alcoholic beverages. For z-proportions test results, bold letters indicate the beverages that were significantly different between countries, while bold numbers indicate the highest percentage of occurrence for the respective country.

Table 3 showed that Mexican participants drink more dark beer, whisky, tequila, and rum than Norwegian participants. Regarding Norway, participants drink more blond beer, white wine, and red wine than Mexican participants.

3.2 Cross-cultural projective mapping

The results from projective mapping analyzed through Generalized Procrustes Analysis (GPA) followed by Agglomerative Hierarchical Clustering (AHC) are shown in Figure 1.

The RV coefficient between the GPA configurations of the two countries was calculated (0.449; *p-value<0.001*), indicating that the coordinates from both countries were not similar, and consequently, that their representation of the food and beverage pairings were not similar either.

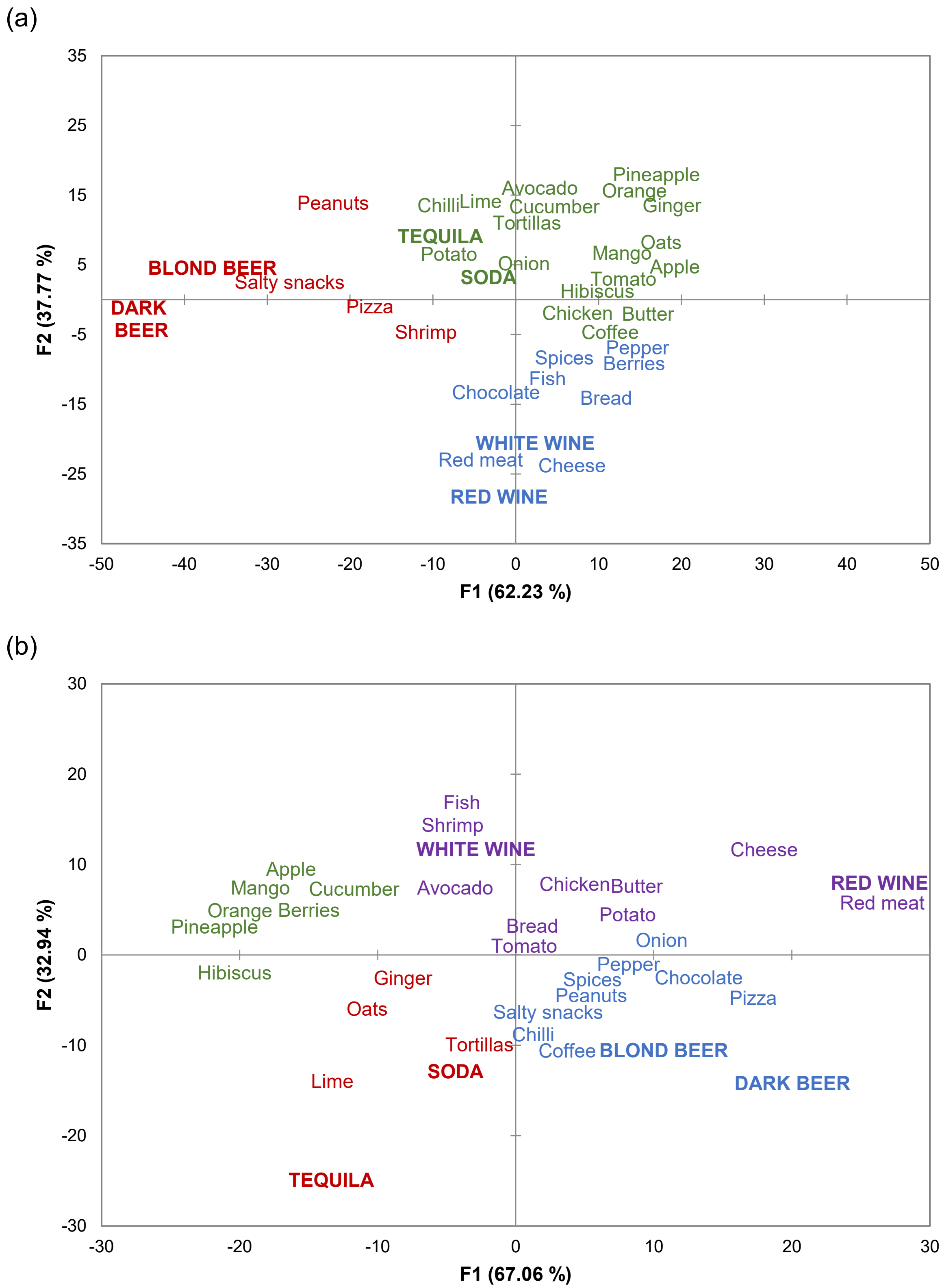


Figure 1. Food-beverage pairing map for (a) Mexico and (b) Norway. The hierarchical clustering (AHC) is represented by similar colors.

Figure 1 shows the food and beverage pairing map for each country, from which several differences and similarities between the food and beverage combinations were found. The results of the AHC showed that for Mexico, the beverages and foods could be clustered into three groups, while for Norway, four groups clustering the beverages and foods were found.

For both countries, the beverages were clustered with different foods that participants combined with them. Both blond and dark beer were clustered in the same group, red and white wine were joined together, and tequila and soda were clustered together. The main difference between the countries is that for Norway, an additional cluster containing only fruits was found, including mango, apple, orange, and pineapple; while for Mexico, almost all these fruits were clustered along with soda and tequila.

Some similarities between the countries could be found regarding the foods that could be paired with each beverage. For instance, both countries could combine blond and dark beer with salty snacks, peanuts, and pizza. In the case of wine, both red and white were clustered along with red meat, cheese, fish, and bread. Finally, for soda and tequila, lime, tortillas, oats, and ginger were clustered together in both countries.

From Figure 2, additional information could be extracted. For each cluster, the closest food items to the beverages represented a better pairing than the food items further to the beverages. Figure 2 shows the dendrogram obtained from the AHC.

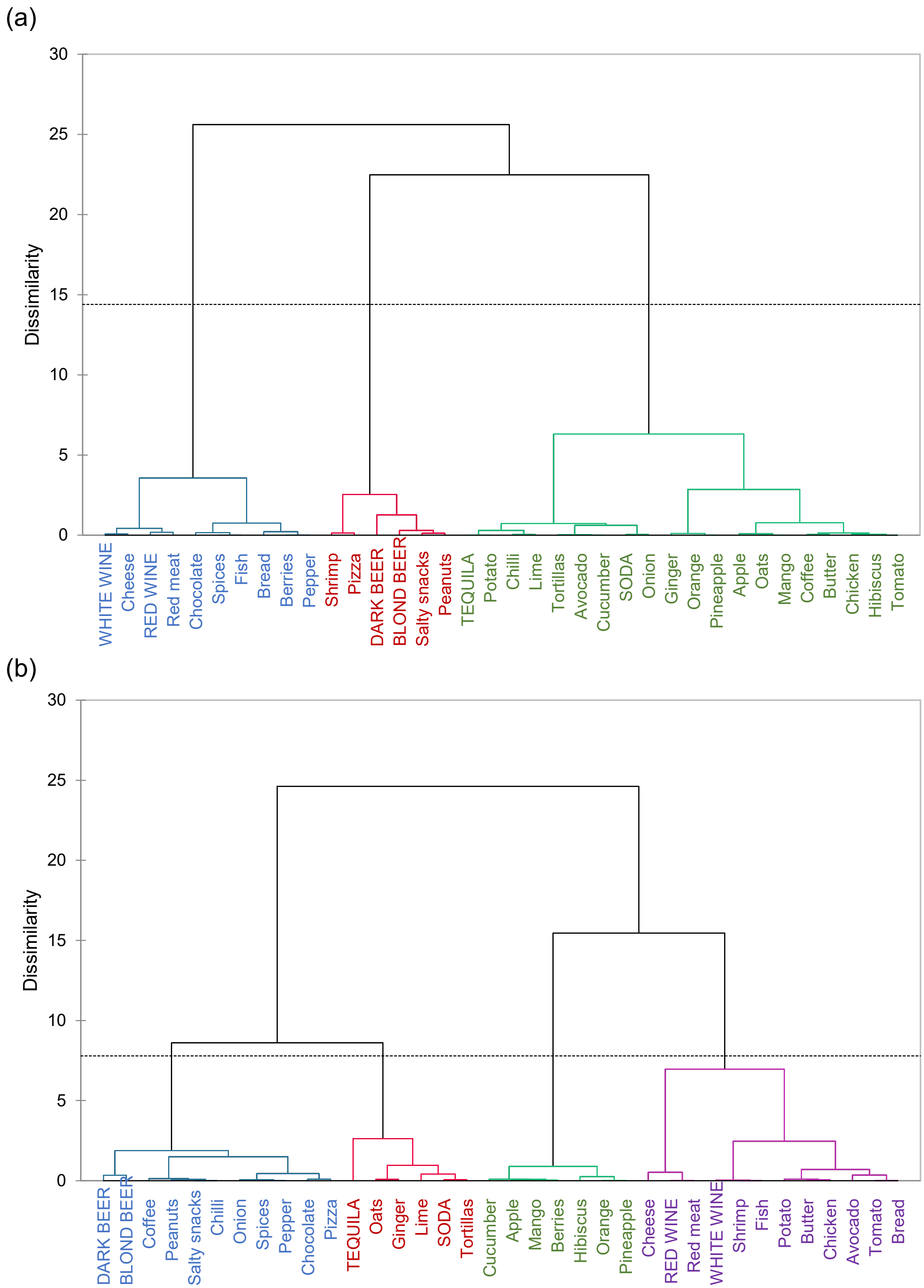


Figure 2. Dendrogram from AHC of GPA of (a) Mexico and (b) Norway. The hierarchical clustering is represented by similar colors.

For Mexico, salty snacks and peanuts were close to blond beer, while pizza and shrimp were close to dark beer. White wine could be combined with cheese while red wine with red meat. tequila pair well with potato, chili, and lime, and soda with onion and cucumber. In the case of Norway, the most consensual pairings were both beers combined with coffee and peanut, tequila with oats and ginger, soda with lime and tortillas, red wine with cheese and red meat, and finally, white wine with shrimp and fish.

4. Discussion

The discussion of this research is divided into two parts: participants' characteristics and cross-cultural projective mapping, which gives an overview of the similarities and differences in food and beverage pairing between countries.

4.1 Participants' characteristics and consumption behavior

Gender influences the habits and preferences of the alcoholic consumption between consumers; therefore, it could play a core role in how much knowledge is held on beer and food pairing (Martínez et al., 2017). In this research, more women than men in both countries responded to the test. According to Euromonitor (2014), many categories of alcoholic beverages in Mexico, such as wine and whiskies, had been growing because of women, in addition, Reséndiz-Escobar et al. (2018) reported that alcohol use in Mexico had been increased, especially among women, which could have impacted the high number of Mexican women that responded the test in this research. The same trend could be observed between Norwegian women; in this line, Bratberg et al. (2016), in their study of examining changes in men‘s and women's alcoholic drinking behavior in Norway over 20 years, showed that mean consumption has been increased in both genders, but slightly more in women than in men.

The age of consumers has also been reported as a factor that influences food/beverage preferences and habits. For example, Garcia et al. (2013) reported that wine is the most frequently consumed beverage among Spanish people over 35 years old, while consumers under 35 frequently consume other drinks, such as beer. For Norway, it has been reported that the annual volume of alcohol consumption among Norwegian participants has increased in all age groups. In this research, most Norwegian participants were women from 18 to 25 years old. Bratberg et al. (2016) reported a tendency of younger women (20-29 years) to have increased their annual consumption disproportionally to men. Moreover, in this study, more Norwegian women from 18 to 25 years old than 26 to 35 years old responded to the test and, in this line, Bratberg et al. (2016) also reported that women aged 30 to 39 years, in general, abstained from drinking alcoholic beverages, which could be related to the period of which most women give birth to and bring up children.

Besides gender, it has been reported that the culture from which we belong influences our food preferences and choices, and therefore, our consumption habits. Thus, in the case of the frequency of consumption, it was found that Norwegian participants drink more frequently alcoholic beverages in a week time lapse than Mexican participants.

While most Mexican participants drink alcoholic beverages once a week, Norwegian participants drink alcoholic beverages one to three times per week. It must be noticed that the amount of alcohol consumed was not registered. However, according to the alcohol consumption reports for Mexico (World Health Organization, 2018a) and Norway (World Health Organization, 2018b), the total alcohol per capita consumption (in liters of pure alcohol) in 2016 was 15.3 and 9.4, for Mexico and Norway, respectively, which suggest that despite Norwegian participants drink alcoholic beverages more frequently than Mexican participants, these last ones could drink them in more quantity.

Alcoholic beverage consumption patterns could vary among different countries. For instance, beer is the beverage of choice for Mexican consumers (Reséndiz-Escobar et al., 2018). According to Euromonitor (2014), beer is the beverage leader in volume terms amongst all alcoholic drinks in Mexico, which agrees with the results of this research, which showed that both dark and blond beer were the most frequently consumed alcoholic beverage between Mexican participants. In the research performed by Gómez-Corona et al. (2016) during a beer festival in Mexico, some of the most consumed alcoholic beverages between Mexican consumers were, from the major to the minor frequency of consumption: beer, whisky, tequila, red wine, vodka, mezcal, rum, brandy, white wine, and pulque (a local fermented beverage). In this research, the frequency of consumption of the evaluated beverages seems to agree with Gómez-Corona et al. (2016), except for both red and white wines, which, in this study, increased their frequency of consumption from 15% to 50% (for red wine) and from 4% to 15% (for white wine). This last trend could be due that despite wine consumption in Mexico is still low compared to other countries in the world (Ruiz, 2017), the Mexican wine has been more consumed in the last years, and it was expected to perform better over the years (Euromonitor, 2014).

In the case of Norwegian participants, wine and beer were the preferred beverages; according to the alcohol consumption report for Norway (World Health Organization, 2018b), wine represented 36% of the alcohol per capita consumption (in liters of pure alcohol) from all the consumed alcoholic beverages, while beer represented the 44%. This trend was in line with the results found in this study, where blond beer had the highest frequency of consumption, closely followed by red wine and white wine. So, in general, as with many types of beverages, the popularity varies by culture, whether the beverage of choice is coffee, tea, wine, beer, or some other beverage (Harrington et al., 2008).

4.2 Cross cultural projective mapping

The RV coefficient found in this study was low (0.449; *p-value<0.001*), indicating that the matrices obtained were not similar and, therefore, the representation of the food and beverage pairing between the countries is essentially different.

Traditions of beverage consumption with specific foods have become a critical factor in distinguishing cuisine (Harrington et al., 2008). Despite the relatively low value of the RV coefficient, some similarities between the AHC of the countries could be found. For instance, for both countries, blond and dark beer could be combined with some foods, such as salty snacks, peanuts, and pizza. Similar behavior has been previously reported by Pettigrew and Charters (2006), where some foods such as pizza, nuts, crisps, fish, and chips were the most mentioned foods to be accompanied with beer. Also, Donadini et al. (2008) suggested that beers are quite suitable for consuming with pizza and fast-food meals.

In the case of wine, both red and white were clustered along with some foods such as cheese, red meat, fish, and bread. The combination of wine and cheese has been widely studied and reported as good food and beverage pairing (King & Cliff, 2005; Bastian et al., 2010; Harrington & Seo, 2015), and in this study, despite similar products were grouped with wine for both countries, from the Mexican dendrogram it could be observed that white wine was close to cheese, while red wine was close to red meat. In the case of Norway, the dendrogram showed that red wine is close to cheese and red meat, while white wine is close to shrimp and fish, which are known to be the most suitable combinations for each type of wine and the usual/classical associations in the French culinary culture (Eschevins et al., 2019). In this sense, the knowledge of a suitable food and wine combination could be reflected by Norwegian participants' higher wine consumption habits than Mexican participants.

In the case of tequila, the dendrogram of Mexico showed that this alcoholic beverage is close to potato, chili, and lime, while soda is close to onion, cucumber, avocado, and tortillas. In this sense, tequila is commonly consumed by Mexican participants along with lime, and this fruit is usually combined with chili, as they are typical flavors in Mexico (Spence, 2017). Regarding the dendrogram for Norway, tequila is close to oats and ginger, while soda is close to tortillas and lime. In addition to these differences, an extra cluster containing only fruits was found in Norwegian information, which could suggest that for Norwegian participants, those fruits (mango, apple, orange, pineapple) do not combine well with any of the beverages tested. Contrarily from Mexico, from which these fruits were clustered along with tequila and soda.

It has been reported that the concept of gastronomic identity is influenced by the environment (geography and climate) and culture (history and ethnic influences) Harrington et al., 2008). For instance, chili, a characteristic flavor in Mexican culture, seemed to be combined with many diverse foods; contrarily from Norway, where chili only appears to be combined with both beers and salty snacks, peanuts, and pizza. In general, several similarities in food and beverage pairing were found among cultures, but also some differences between Mexican and Norwegian consumer perceptions, which could reflect the variability and influence of culture in the appropriateness of certain food and beverage combinations.

This approach only considered consumer perceptions, which essentially may rely on consumption habits in each culture. Projective mapping allowed us to visualize the differences attributed to culture for food and beverage pairing' preferences between participants.

The set of products was selected due to popularity among Mexican consumers; therefore, it could be pertinent to explore a different set of products popular among Norwegian consumers. In addition, the instructions of the test were "to position each food on the screen so that the food' positions reflected better combinations between foods and beverages," however, it has been reported that when a consumer does not know a specific beverage that would pair well with their meal, they turn to their subjective knowledge of what they think tastes good (Harrington et al., 2008). This fact could explain some of the food and beverage combinations between Norwegian participants since some beverages, such as tequila, are commonly consumed in Mexico but maybe not well known or frequently consumed between Norwegian participants. Therefore, this approach could provide an overview of what some consumers anticipated as a suitable food and beverage pairing based on their previous experiences or what they think tastes good.

Conclusions

In general, some pairings were similar between countries, and some others were characteristic of each culture. Overall, projective mapping allowed to obtain maps of food and beverage pairings and compare the perceptions between participants of different countries. However, further research should include more countries or a different set of products in order to analyze and find more similar/different patterns between cultures and, therefore, gain more understanding of the food and beverage pairing field. This research showed that cultural differences regarding food and beverage pairing could be explored by applying projective mapping as a consumer-oriented method, from which food and beverage pairing maps could be successfully obtained.

Acknowledgments

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

Paula Varela: Conceptualization, Methodology, Supervision, and Writing-Reviewing and Editing.

Carlos Gómez-Corona: Conceptualization, Supervision, and Writing-Reviewing and Editing.

Héctor B. Escalona-Buendía: Conceptualization, Supervision, and Writing-Reviewing and Editing.

Araceli Arellano-Covarrubias: Methodology, Formal Analysis, Investigation, and Writing-Original draft preparation

References

Addinsoft (2019). XLSTAT statistical and data analysis solution. Long Island, NY, USA. https://www.xlstat.com.q

Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A.-L. (2011). Flavor network and the principles of food pairing. *Scientific Reports,* 1, 196. https://doi.org/10.1038/srep00196.

Arellano-Covarrubias, A., Gómez-Corona, C., Varela, P., & Escalona-Buendía, H.B. (2019). Connecting flavors in social media: A cross cultural study with beer pairing. *Food Research International,* 115, 303-310. https://doi.org/10.1016/j.foodres.2018.12.004.

Bastian, S. E. P., Collins, C., & Jhonson, T. E. (2010). Understanding consumer preferences for Shiraz wine and Cheddar cheese pairings. *Food Quality and Preference,* 21, 668-678. https://doi.org/10.1016/j.foodqual.2010.02.002.

Blancher, G., Clavier, B., Ergoroff, C., Duineveld, K., & Parcon, J. (2012). A method to investigate the stability of a sorting map. Food Quality and Preference, 23, 36–43. https://doi.org/10.1016/j.foodqual.2011.06.010.

Bratberg, G. H., Wilsnack, S. C., Wilsnack, R., Haugland, S. H., Krokstad, S., Sund, E. S. & Bjørngaard, J. H. (2016). Gender differences and gender convergence in alcohol use over the past three decades (1984–2008), The HUNT Study, Norway. *BMC Public Health,* 16, 723. https://doi.org/10.1186/s12889-016-3384-3.

Christensen, M. & Stuart, R. E. (2019). Teaching science to chefs: The benefits, challenges and opportunities. *International Journal of Gastronomy and Food Science,* 16. https://doi.org/10.1016/j.ijgfs.2019.01.001.

Donadini, G., Fumi, M. D. & Lambri, M. (2012). The hedonic response to chocolate and beverage pairing: A preliminary study. *Food Research International*. 48:2, 703-711. https://doi.org/10.1016/j.foodres.2012.06.009.

Donadini, G., Fumi, M. D. & Lambri, M. (2013). A preliminary study investigating consumer preference for cheese and beer pairings. *Food Quality and Preference,* 30, 217-228. https://doi.org/10.1016/j.foodqual.2013.05.012

Donadini, G., Spigno, G., Fumi, M. D., Pastori, R. (2008). Evaluation of ideal everyday Italian food and beer pairings with regular consumers and food and beverages experts. *Journal of Institute of Brewing.* 114:4, 329-342. https://doi.org/10.1002/j.2050-0416.2008.tb00777.x.

Eschevins, A., Giboreau, A., Allard, T., Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference,* 65, 18-27. https://doi.org/10.1016/j.foodqual.2017.12.005.

Eschevins, A., Giboreau, A., Julien, P., Dacremont, C. (2019). From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer. *International Journal of Gastronomy and Food Science,* 17 https://doi.org/10.1016/j.ijgfs.2019.100144.

Euromonitor International (2014). Alcoholic drinks in Mexico. Retrieved from: Euromonitor Passport database. London: Euromonitor International.

Galmarini, M. V. (2020). The role of sensory science in the evaluation of food pairing. *Current opinion in Food Science,* 33, 149-155. https://doi.org/10.1016/j.cofs.2020.05.003.

Garcia, T., Barrena, R. & Grande Ildefonso. (2013). The wine Consumption preferences of young people: a Spanish case study. *International Journal of Wine Business Research,* 25:2, 94-107. https://doi.org/10.1108/IJWBR-2012-0007.

Gómez-Corona, C., Escalona-Buendía, H. B., García, M., Chollet, S., & Valentin, D. (2016). Craft vs. industrial: Habits, attitudes and motivations towards beer consumption in Mexico. Appetite, 96, 358-367. https://doi.org/10.1016/j.appet.2015.10.002.

Harrington, R. J. (2005). Defining gastronomic identity. *Journal of Culinary Science & Technology, 4, 2-3.* https://doi.org/10.1300/J385v04n02_10.

Harrington, R. J., Miszczak, D. C., & Ottenbacher, M. C. (2008). The impact of beer type, pizza spiciness and gender on match perceptions. PASOS. *Revista de Turismo y Patrimonio Cultural,* 6:2, 173-188.

Harrington, R.J. & Seo, H-S (2015). The impact of liking of wine and food items on perceptions of wine-food pairing. *Journal of Foodservice Business Research,* 18,5, 489-501. https://doi.org/10.1080/15378020.2015.1093455.

Holm, L., Lauridsen, D. S., Gronow, J., Kahma, N., Kjærnes, U., Lund, T. B., Mäkelä, J. & Niva, M. (2019). The food we eat in Nordic countries-some changes between 1997 and 2012. In Holm, L., Lund, T., Gronow, J. & Lauridsen, D. (eds.) *The social context and conducting of eating*

Holm L, Lauridsen DS, Gronow J, Kahma N, Kjærnes U, Lund TB, Mäkelä J, Niva M (2019) The food we eat. In: *Everyday eating in Denmark, Finland, Norway and Sweden. A comparative study of meal patterns 1997–2012*, ed. by Gronow J, Holm L, 15–31. London & New York: Bloomsbury Academic

Jain, A., N. K., R. & Bagler, G. (2015). Analysis of food pairing in regional cuisines of India. *PLoS ONE,* 10,10. https://doi.org/10.1371/journal.pone.0139539.

Kim, H-J., Chung, S-J., Kim, K-O., Nielsen, B., Ishii, R. & Michael O'Mahony (2018). A cross-cultural study of acceptability and food pairing for hot sauces. *Appetite,* 123, 306-316. https://doi.org/10.1016/j.appet.2018.01.006.

King, M. & Cliff, M. (2005). Evaluation of ideal wine and cheese pairs using a deviation-from-ideal scale with food and wine experts. *Journal of Food Quality,* 28, 245-256. https://doi.org/10.1111/j.1745-4557.2005.00033.x.

Klepper, M. (2011). Food pairing theory: A European fad. *Gastronomica*, 11(4), 55–58. https://doi.org/10.1525/gfc.2012.11.4.55

Kort, M., Nijssen, B., van Ingen-Visscher, K., & Donders, J. (2010). Food pairing from the perspective of the "Volatile compounds in food" database. *Expression of Multidisciplinary Flavour Science: Proceedings of the 12th Weurman Symposium, Interlaken, Switzerland, 589-592.*

Köster, E. G. (2003). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14, 359-373.* https://doi.org/10.1016/S0950-3293(03)00017-X

Köster, E. P. & Mojet, J. (2006). Theories of food choice development. In Frewer, L.J., van Trijp, J.C.M. *Understanding consumers of food products*. Cambridge: Woodhead.

Lahne, J. (2018). Evaluation of meals and food pairing. In Lahne, J. (eds), *Methods of Consumer Research, Volume 2.*

Martínez, D. C., Hammond, R.K., Harrington, R.J. & Wiersma-Mosley, J. D. (2017). Young adult's and industry expert's subjective and objective knowledge of beer and food pairings. *Journal of Culinary Science & Technology,* 15, 4, 285-305. https://doi.org/10.1080/15428052.2016.1256243.

Pettigrew, S., & Charters, S. (2006). Consumers' expectations of food and alcohol pairing. *British Food Journal,* 108:3, 169-180. https://doi.org/10.1108/00070700610650990.

Reséndiz Escobar, E., Bustos Gamiño, M. N., Mujica Salazar, R., Soto Hernández, I. S., Cañas Martínez, V., Fleiz Bautista, C., Gutiérrez López, M. de L., Amador Buenabad, N., Medina-Mora, M. E., Villatoro Velázquez, J. A. (2018). National trends in alcohol consumption in Mexico: results of the National Survey on drug, alcohol and tobacco consumption 2016-2017. *Salud Mental, 41, 1, 7-15.* https://doi.org/10.17711/SM.0185-3325.2018.003

Rojas-Rivas, E., Rendón-Domínguez, A., Felipe-Salinas, J. A. Cuffia, F. (2020). What is gastronomy? An exploratory study of social representation of gastronomy and Mexican cuisine among experts and consumers using a qualitative approach. *Food Quality and Preference,* 83. https://doi.org/10.1016/j.foodqual.2020.103930.

Rozin, P. (2002) Human food intake and choice: Biological, Psychological, and Cultural Perspectives. In H. Anderson, J. Blundell, & M. Chiva (eds.) *Food selection: From genes to culture*. (pp. 7-24). Paris: Danone Institute.

Rozin, P. (2005). The meaning of food in our lives: A cross-cultural perspective on eating and well-being. *Journal of Nutrition Education and Behavior,* Suppl 2:S107-12. https://doi.org/10.1016/s1499-4046(06)60209-1.

Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion,* 4, 77–101.

Ruiz, L. M. (2017). Preferences in wine consumption in Mexico, wine tourism and chances of success for winemakers entrepreneurs. *Turismo: Estudos & Práticas (RTEP/UERN),* 6, 1. http://periodicos.uern.br/index.php/turismo/article/view/2560

Sánchez-Cañizares, S. M. & López-Guzmán, T. (2012). Gastronomy as a tourism resource: profile of the culinary tourist. *Current issues in Tourism,* 229-245. http://dx.doi.org/10.1080/13683500.2011.589895.

Spence, CH (2020). Food and beverage flavour pairing: Acritical review of the literature. *Food Research International, 133, 109124. https://doi.org/10.1016/j.foodres.2020.109124.*

Spence, CH. (2020). Food and beverage flavour pairing: Acritical review of the literature. *Food Research International,* 133, 109124. https://doi.org/10.1016/j.foodres.2020.109124.

Spence, Ch., Wang, Q. J. & Youssef, J. (2017). Pairing flavours and the temporal order of tasting. *Flavour,* 6,4. https://doi.org/10.1186/s13411-017-0053-0

Silva, T. H., Vaz de Melo, P. O. S., Almeida, J., Musolesi, M., Loureiro, A. (2014). You are what you eat (and drink): Identifying cultural boundaries by analyzing food and drink habits in Foursquare. *Proceedings of the Eighth International AAAI Conference on Weblogs and Social Media*

Simas, T., Ficek, M., Diaz-Guilera, A., Obrador, P., & Rodriguez, P. R. (2017). Food bridging: a new network construction to unveil the principles of cooking. *Frontiers in ICT,* 4,14. https://doi.org/10.3389/fict.2017.00014.

Tallab, S. T. & Alrazgan, M. S. (2016). Exploring the food pairing hypothesis in Arab cuisine: A study in computational gastronomy. *Procedia Computer Science,* 82,135-137. https://doi.org/10.1016/j.procs.2016.04.020

Varshney, K. R., Varshney, L. R., Wang, J., & Myers, D. (2013). Flavor pairing in Medieval European cuisine: A study in cooking with dirty data. *arXiv:1307.7982. [physics.soc-ph].*

Vidal, L., Jaeger, S. R., Ares, G. (2014, November). What is the best parameter to estimate the degree of similarity between two-dimensional sample configurations?. Poster session presentation at Sensometrics 2014, Chicago.

World Health Organization (2018a). https://www.who.int/substance_abuse/publications/global_alcohol_report/profiles/mex.pdf?ua=1, Accessed date: 02 September 2021.

World Health Organization (2018b) https://www.who.int/substance_abuse/publications/global_alcohol_report/profiles/nor.pdf, Accessed date: 02 September 2021.

General discussion

This thesis arises from the need to better understand food and beverage pairing and explore sensory techniques that evaluate the preferred food combinations among consumers across cultures. The four chapters developed in this thesis intend to answer some of the open questions in the food pairing field from a consumer perception perspective, including cross-cultural influence. Therefore, the general discussion will be focused on three central aspects: food and beverage pairing from a consumer perspective, cross-cultural research, and finally, the methodological considerations in food and beverage pairing exploration.

Food and beverage pairing from a consumer perspective

In developing this thesis, we had an overview of the most popular foods that some Latin American and Norwegian participants could combine with some beverages, such as beer and wine. Each chapter was shown to contribute to the general understanding of food and beverage information.

Chapter 1 showed that food and beverage pairing could be explored by accessing social media. The frequency of occurrence of different foods made it possible to identify the most popular foods that consumers from Latin American countries considered suitable pairings with beer. Detailed analysis of the obtained social media information should be considered, due to the fact that not all the associations found were related to food and beverage pairings.

In chapter 2, in order to study the food and beverage pairing from social media posts in greater depth, the exploration, through content analysis, of a sample of images and texts previously extracted from chapter 1 was conducted. This approach allowed specific food and beverage combinations among Mexican consumers to be identified. Different simpler foods (lime, chili, pineapple) and complex meals, such as pizza and burgers, were explored. In general, social media as a source of information made possible the exploration of food and beverage pairing in different situations.

In chapters 3 and 4, the projective mapping technique was applied with Mexican and Norwegian frequent and occasional consumers of alcoholic beverages, with the objective of exploring food and beverage preferences. Samples were not tasted. So sensory perception aspects of the products were not evaluated, only the consumer's expectations, perceptions, and preferences of food and beverage combinations as per experience and memory. In addition, consumers did not receive a description of what a "good combination" is. No definitions of an ideal match, balance, harmony, complementary, or similarity matching in the products were provided, which helped avoid bias in participant's perception towards certain combinations and results only focused on the top of mind, undirected perception.

In the case of chapter 3, the use of images in the projective mapping task acted as a guide for consumers' perception homogeneity. This chapter provides an overview of what consumers perceived as a suitable food and beverage pairing based on their previous experiences, familiar combinations, memory, or culturally accepted pairings. So, in general, the fact that participants did not taste any product gave them access to a series of mental constructs of what a good pairing is for them.

Chapters 3 and 4 showed that Mexican and Norwegian perceptions for specific food and beverage pairing were successfully explored by applying a projective mapping task, and then compared. From chapter 4, similarities and differences in how Mexican and Norwegian participants pair food and beverages were found, which could be considered the main food and beverage pairings according to consumer perceptions. For example, both Mexican and Norwegian participants pair beer with similar food products, while wine pairings were different between the participants of different cultures. Additionally, some food items paired better than others with certain beverages (e.g., For Norwegian participants, red wine was a good pair with cheese and red meat, while white wine was a good pair with shrimp and fish). In the case of Norwegian participants, the knowledge of a suitable food and wine combination could be reflected by a higher wine consumption than in Mexican participants. The main results of food and beverage pairing from Mexican participants showed that each beverage could be clustered in a different group with specific food items, showing that the beverages were not similar in terms of perception.

Furthermore, the food products closer to the beverages reflected the foods that combined the best with each beverage in consumers' minds. So, in general, this approach provided an overview of what some consumers anticipated as a suitable food and beverage pairing, based on their previous experiences or what they think tastes good.

Particular attention should be given to food pairings with beverages that are more commonly known and consumed among participants, as this could influence the pairings. For example, tequila and soda were suitable for being paired with several food products among Mexican participants but were only paired with a few products among Norwegian participants (chapter 4). In general, the food and beverage pairings found in this thesis were consistent with some pairings reported for each culture. Moreover, in the case of Mexico, results were also consistent across the thesis, which served as a way to validate our findings.

Cross-cultural research

The exploration of the cultural influence was addressed in chapters 1 and 4. Chapter 1 showed that several differences could be found between countries, despite Latin American cultures speaking the same language. In the case of chapter 4, similar results were obtained. The comparison of Mexico and Norway showed that participants differed in food and beverage perceptions (given by the low RV coefficient value). These findings support the well-known statement that culture influences our food choices and preferences.

Some similarities and differences between countries were found, reflecting that food and beverage pairing could also be culturally influenced and has transcended over the years. For example, chili consumption has been widespread worldwide in different cuisines (Spence, 2018). However, chili is still the main characteristic of Mexican cuisine (Rozin, 1990; Katz, 2009) and has remained since pre-Columbian times, along with other food products such as coriander and lime (Spence, 2017).

In general, the assessment of social media and projective mapping methodologies were helpful in the food-beverage exploration between different cultures, which was a relevant aspect in the development of this thesis. What is more, it was found that there might be some characteristic food-beverage pairings that are more popular in some cuisines than in others, which could be related to the culture to which we belong. In this line, as Donadini et al. (2008) and Harrington (2005b) stated before, food and beverage pairing is not random, since some foods were found to combine better than others with specific beverages between cultures.

Methodological considerations on food and beverage pairing exploration

Sensory evaluation has evolved into a complex, multidisciplinary field that requires a high degree of scientific knowledge and skill to be carried out successfully (Kemp, 2008). Proof of this is the variety of new techniques and approaches that have been developed in the last few years. In the case of food and beverage pairing, the exploration of non-traditional methodologies turned out to be valuable tools in developing this thesis.

Social media was used to research the relationship between food and beer pairings across countries. Chapter 1 showed that a large quantity of information could be extracted from social media and mainstream data. In this chapter, social media allowed specific food associations per country to be identified. Also, a cultural relevance was observed, given by the differences and similarities in pairings between countries.

From the extracted social media posts in chapter 1, the frequency of co-occurrence of foods was used to measure the consumer preference for food and beer pairing; however, it could also be taken as a disadvantage of the method. For instance, some food combinations were not relevant in order to study associations between foods or between food and beer, such as peanut-butter, coffee- toasted, so the results require careful interpretation. Furthermore, in some cases, the mention of certain beverages was only as a consumption option between multiple alcoholic beverages or as a sequence of beverages consumption (e.g., “My diet today: cake and coffee, cheese snack, beer, peanuts, and a cigar”; “beer and wine, in that order”; “Yesterday, I drank beer, wine, tequila, whisky, schnapps, and piña colada, I went to bed at 7 am!”).

Chapter 2 intended to avoid these aforementioned disadvantages by accessing a set of tweets and Instagram images from Mexican users to extract accurate food and beer pairings following text and image analysis. In addition, photography from social media is gaining relevance in the gastronomy field due to the user's fascination with taking pictures before eating food and meals.

Chapter 2 showed that images from social media resulted in a complete source of information regarding beer food pairing, particularly with regards to the context of consumption like the social setting, place, or meal composition. Therefore, researchers could also access consumer practices and food culture by accessing food images, while avoiding laboratory settings. However, some aspects should be considered.

In the case of the information obtained, some advantages of using social media as a source of information could be highlighted. First, we could extract a set of popular food products, and second, we could explore the relationship between beer-food pairing across countries. In addition, we accessed a large number of countries and information with a minimal investment of money and time in the data extraction. However, the main disadvantage was the time investment of researchers in cleaning and selecting the relevant information in the posts. Therefore, data analysis needs to be improved to facilitate and shorten the time invested in analyzing image by image. Integrating other disciplines specialized in images, such as arts, design, and semiotics could improve how we use images for consumer research. Another disadvantage is that, in most cases, the demographic information of the users could not be fully obtained from the user profiles. Another aspect to consider is that social media could reflect "idealized situations," which may not reflect real food habits or consumption; what is more, the information obtained may only represent special food occasions.

Another approach proposed by this thesis was projective mapping as a research tool to test a set of products diverse in nature. This approach made it possible to obtain a whole map of food and beverage pairings, according to Mexican (chapter 3) and Norwegian (chapter 4) participants' perceptions. The projective mapping technique was adapted. In the original task, the positions of the products reflect a similar structure. In this thesis, the positions of the products reflected food and beverage pairings: the shortest distance between two products represented a suitable food and beverage pairing among participants, and on the contrary, the largest distance between two products represented a non-suitable food and beverage pairing. The adaptation of projective mapping provided evidence of it being suitable for exploring food and beverage pairings.

In chapter 4, an online projective mapping was applied to 100 Mexican consumers, using a code to identify the food and beverage products. The main disadvantage of using codes instead of complete names is that for consumers it was more challenging to visualize and perform the projective mapping task. In the case of Norwegian projective mapping, complete names of the products were included, which facilitates the performance of the task. For comparison purposes, an RV coefficient was performed (not shown in either chapter 3 or 4) between the coordinates of GPA from chapter 3 and the GPA's coordinates of Mexican participants from chapter 4 (online vs. face-to-face projective mapping). The result of the RV coefficient between the coordinates was relatively high (0.716; $p\text{-}value<0.001$), indicating that both GPA coordinates were quite similar. Therefore, the Mexican participants who performed the face-to-face projective mapping task and those who answered it online had similar perceptions and preferences for particular food and beverage pairings. This result provides additional evidence of the suitability of projective mapping in exploring food and beverage pairings among consumers. The RV coefficient showed that both online and face-to-face approaches could be successfully replicated and could obtain similar outcomes (with at least 100 participants).

The implementation of projective mapping allowed the simultaneous evaluation of different products for exploring food-food and food-beverage pairings. One aspect to consider is that a pairing usually starts with the food, and it is the beverage that accompanies it. Here, however, we inverted the task as our research interest was exploring which foods would pair well with specific beverages. Also, it was more manageable for consumers to start with visualizing the six beverages instead of the thirty food items. In the case of the images used in chapter 3, we are aware that an image will never substitute all the different flavors and associations that arise from the taste perceptions of real food and beverages. Therefore, additional research should explore if the pairings found in the projective mapping task with images and names agree with the pairings of real food products. Moreover, research assessing different food and beverage products could be of great value to the gastronomy field.

In developing this thesis, broad relevance has been given to the cultural influence on food and beverage pairing. In addition, it has been shown that consumer preferences for certain food and beverage pairings could be culturally influenced. Therefore, further research should be done by comparing more countries, similar or different in culture, in order to test the differences or similarities in food and beverage pairing more widely.

General conclusions

Food pairing has been a popular topic in the gastronomic sector, sometimes combined with beverages; however, sensory science has not studied food and beverage pairings widely. In this thesis, new methodological approaches to study consumer perception were explored from a cross-cultural perspective. From a methodological consumer research perspective, it was shown that social media and online tests could act as valuable tools which consumer science and food pairing fields could take advantage of. Particular attention should be given to the exploration of image-based platforms which could provide detailed information regarding food and beverage pairing. In addition, this thesis showed that implementing techniques that have not been used in the food pairing research, such as projective mapping, could provide consistent and repeatable results. Projective mapping allowed the exploration of what consumers think is a suitable food and beverage pairing, based on their previous experiences. In addition, it allowed a set of different food and beverage products to be tested by only evaluating consumer perceptions. Further research should validate whether the pairings found in this thesis agree with the pairings of real food and beverages.

From a cultural perspective, this thesis demonstrated the cultural diversity of food preferences in different cuisines; however, some similar elements could be identified. To be considered: the food and beverage pairing found in the development of this thesis was based only on consumer expectations, preferences, and perceptions, which could be influenced by culture. Future research is needed to explore all the underlying variables that influence the food and beverage pairing, which may lead to a better understanding of cultural similarities and differences between consumer preferences.

References

Ahn, Y.-Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A.-L. (2011). Flavor network and the principles of food pairing. *Scientific Reports,* 1(196).

Ahnert, S. E. (2013). Network analysis and data mining in food science: the emergence of computational gastronomy. *Flavour*, 2,4. https://doi.org/10.1186/2044-7248-2-4.

Arellano-Covarrubias, A., Varela, P., Escalona-Buendía, H.B. & Gómez-Corona, C. (2022). A food and beverage map: Exploring food-beverage pairing through projective mapping. *Food Quality and Preference,* 96, 104431. https://doi.org/10.1016/j.foodqual.2021.104431.

Ares, G. (2016). Methodological issues in cross-cultural sensory and consumer research. *Food Quality and Preference.* http://dx.doi.org/10.1016/j.foodqual.2016.10.007

Bastian, S., Payne, B., Joscelyne, V., & Johnson, T. (2009). Comparisons between Australian consumer's and industry expert's perceptions of ideal wine and cheese combinations. *Australian Journal of Grape and Wine Research,* 15, 175–184.

Bastian, S. E. P., Collins, C., & Jhonson, T. E. (2010). Understanding consumer preferences for Shiraz wine and Cheddar cheese pairings. *Food Quality and Preference,* 21, 668-678. https://doi.org/10.1016/j.foodqual.2010.02.002.

Bujdosó, Z. & Szücs, C. (2012). Beer tourism- from theory to practice. *Academica Turística-Tourism and Innovation Journal,* 5,1, 103-111.

Cerretani, L., Biasini, G., Bonoli-Carbognin, M. & Bendini, A. (2007). Harmony of virgin oil and food pairing: A methodological proposal. *Journal of Sensory Studies,* 22, 403-416. https://doi.org/10.1111/j.1745-459X.2007.00115.x.

Cruwys, T., Bevelander, K. E. & Hermans, R. C.J. (2015). Social modelling of eating: A review of when and why social influence affects food and intake choice. *Appetite,* 86, 3-18. http://dx.doi.org/10.1016/j.appet.2014.08.035.

Donadini, G., Spigno, G., Fumi, M. D., Pastori, R. (2008). Evaluation of ideal everyday Italian food and beer pairings with regular consumers and food and beverages experts.

Journal of Institute of Brewing, 114(4), 329-342. https://doi.org/10.1002/j.2050-0416.2008.tb00777.x.

Donadini, G., Fumi, M. D. & Lambri, M. (2012). The hedonic response to chocolate and beverage pairing: A preliminary study. *Food Research International*. 48:2, 703-711. https://doi.org/10.1016/j.foodres.2012.06.009.

Donadini, G., Fumi, M. D. & Lambri, M. (2013). A preliminary study investigating consumer preference for cheese and beer pairings. *Food Quality and Preference,* 30, 217-228. https://doi.org/10.1016/j.foodqual.2013.05.012

Donadini, G., & Fumi, M. D. (2014). An investigation on the appropriateness of chocolate to match tea and coffee. *Food Research International,* 63, 464–476. https://doi.org/10.1016/j.foodres.2014.05.038

Eschevins, A., Giboreau, A., Allard, T., Dacremont, C. (2018). The role of aromatic similarity in food and beverage pairing. *Food Quality and Preference,* 65, 18-27. https://doi.org/10.1016/j.foodqual.2017.12.005

Eschevins, A., Giboreau, A., Julien, P., Dacremont, C. (2019). From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer. *International Journal of Gastronomy and Food Science,* 17 https://doi.org/10.1016/j.ijgfs.2019.100144.

Euromonitor International (2017). Beer in Latin America. Retrieved from: Euromonitor Passport database. London: Euromonitor International.

Euromonitor International (2017). Alcoholic drinks in Mexico. Retrieved from: Euromonitor Passport database. London: Euromonitor International.

Galiñanes, A., Delarue, J., Saulais, L. (2019). The pursuit of ecological validity through contextual methodologies. *Food Quality and Preference,* 73, 226-247. https://doi.org/10.1016/j.foodqual.2018.11.004

Galmarini, M. V., Loiseau, A-L., Debreyer, D., Visalli, M., & Schlich, P. (2017). Use of multi-intake Temporal Dominance of Sensations (TDS) to evaluate the influence of wine on cheese perception. *Journal of Food Science,* 82:11, 2669-2678. https://doi.org/10.1111/1750-3841.13500.

Galmarini, M. V. (2020). The role of sensory science in the evaluation of food pairing. *Current opinion in Food Science,* 33, 149-155. https://doi.org/10.1016/j.cofs.2020.05.003.

Gnambs, T. & Kaspar, K. (2015). Disclosure of sensitive behaviors across self-administered survey modes: a meta-analysis. *Behavior Research Methods*, 47,4, 1237-1259. https://doi.org/10.3758/s13428-014-0533-4.

Gómez-Corona, C., Escalona-Buendía, H. B., García, M., Chollet, S., & Valentin, D. (2016). Craft vs. industrial: Habits, attitudes and motivations towards beer consumption in Mexico. *Appetite*, 96, 358-367. https://doi.org/10.1016/j.appet.2015.10.002.

Gómez-Corona, C. & Valentin, D. (2019). An experiential culture: A review on user, product, drinking and eating experiences in consumer research. *Food Research Intrernational,* 115, 3328-337. https://doi.org/10.1016/j.foodres.2018.11.035.

Harrington, R. J., Miszczak, D. C., & Ottenbacher, M. C. (2008). The impact of beer type, pizza spiciness and gender on match perceptions. PASOS. *Revista de Turismo y Patrimonio Cultural,* 6:2, 173-188. https://doi.org/10.25145/j.pasos.2008.06.014.

Harrington, R. J., McCarthy, M., & Gozzi, M. (2010). Perceived match of wine and cheese and the impact of additional food elements: A preliminary study. *Journal of Food Service Business Research,* 13(4), 311–330.

Harrington, R.J. & Seo, H-S (2015). The impact of liking of wine and food items on perceptions of wine-food pairing. *Journal of Foodservice Business Research,* 18,5, 489-501. https://doi.org/10.1080/15378020.2015.1093455.

Harrington, R. J. &Ottenbacher, M. C. (2010). Culinary tourism- A case study of the gastronomic capital. *Journal of Culinary Science and Technology,* 8,1, 14-32. http://dx.doi.org/10.1080/15428052.2010.490765.

Harrington, R. J. (2005a). Defining gastronomic identity. *Journal of Culinary Science &*

Harrington, R. J. (2005a). Defining gastronomic identity. *Journal of Culinary Science & Technology, 4, 2-3.* https://doi.org/10.1300/J385v04n02_10.

Harrington, R. J. & Hammond, R. (2005b). The direct effects of wine and cheese characteristics on perceived match. *Journal of Food Service Business Research,* 8,4, 37-54. https://doi.org/10.1300/J369v08n04_04.

Herdenstam, A. P. F., Hammarén, M., Ahlström, R., & Per-Axel, W. (2009). The professional language of wine: Perception, training and dialogue. *Journal of Wine Research,* 21:1, 53-84. http://dx.doi.org/10.1080/09571260902978543.

Herrera, J. C. S. (2021). The contribution of network science to the study of food recipes. A review paper. *Appetite,* 159, 1-11. https://doi.org/10.1016/j.appet.2020.105048.

Holmberg, C., Chapli, J. E., Hillman, T. & Berg, C. (2016). Adolescents' presentation of food in social media: An explorative study. *Appetite,* 99, 121-129. https://doi.org/10.1016/j.appet.2016.01.009.

Jain, A., N. K., R. & Bagler, G. (2015). Analysis of food pairing in regional cuisines of India. PLoS ONE, 10,10. https://doi.org/10.1371/journal.pone.0139539.

Jain, V. & Gupta, K. (2005). Food and nutritional analysis. In *Encyclopedia of Analytical Science* (Second Edition), 2005.

Jeong S, Lee J. (2021). Effects of cultural background on consumer perception and acceptability of foods and drinks: A review of latest cross-cultural studies. *Current Opinion in Food Science,* 42, 248-256. https://doi.org/10.1016/j.cofs.2021.07.004.

Kemp, S. (2008). Application of sensory evaluation in food research. *International Journal of Food Science and Technology,* 43, 1507-1511. https://doi.org/10.1111/j.1365-2621.2008.01780.x.

Kim, H-J., Chung, S-J., Kim, K-O., Nielsen, B., Ishii, R., O'Mahony, M. (2018). A cross-cultural study of acceptability and food pairing for hot sauces. *Appetite,* 123, 306-316. https://doi.org/10.1016/j.appet.2018.01.006.

King, M. & Cliff, M. (2005). Evaluation of ideal wine and cheese pairs using a deviation-from-ideal scale with food and wine experts. *Journal of Food Quality,* 28, 245-256. https://doi.org/10.1111/j.1745-4557.2005.00033.x

Klepper, M. (2011). Food pairing theory: A European fad. *Gastronomica*, 11(4), 55–58. https://doi.org/10.1525/gfc.2012.11.4.55

Köster, E. G. (2003). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14, 359-373.* https://doi.org/10.1016/S0950-3293(03)00017-X

Kort, M., Nijssen, B., van Ingen-Visscher, K. & Donders, J.(2008). Food pairing from the perspective of the “volatile compounds in food” database.

Rozin, P. (1996). Sociocultural influences on human food selection. In E. D. Capaldi (Ed.), Why we eat what we eat: The psychology of eating (pp. 233–263). *American Psychological Association.* https://doi.org/10.1037/10291-009

Lahne, J. (2018). Evaluation of meals and food pairing. In *Methods in Consumer Research, Volume 2.* Alternatives Approaches and Special Applications. (pp. 85-107). https://doi.org/10.1016/B978-0-08-101743-2.00004-2

Liu, T-T., Yang, T-S. (2002). Optimization of solid-phase microextraction analysis for studying change of headspace flavor compounds of banana ripening. *Journal of Agricultural and Food Chemistry,* 50, 653-657. https://doi.org/10.1021/jf010891.

Lobzhanidze, A., Zeng, W., Gentry, P., & Taylor, A. (2013). Mainstream vs. social media for trending topic prediction-an experimental study. *Consumer and Communications and Networking Conference (CCNC), 2013 IEEE.IEEE* (pp. 729–732).

Martínez, D. C., Hammond, R.K., Harrington, R.J. & Wiersma-Mosley, J. D. (2017). Young adult’s and industry expert’s subjective and objective knowledge of beer and food pairings. *Journal of Culinary Science & Technology,* 15,4, 285-305. https://doi.org/10.1080/15428052.2016.1256243.

Madrigal-Galán, B. & Heymann, H. (2006). Sensory effects of consuming cheese prior to evaluating red wine flavor. *American Journal of Enology and Viticulture,* 57:1, 12-22.

Makinei, L. V., Rizwana, S., Hazarika, M. K. (2021). Application of flavor network principle of food pairing to Assamese Cuisine from North East India. *International Journal of Gastronomy and Food Science* https://doi.org/10.1016/j.ijgfs.2021.100426.

Meiselman, H. L. (2013). The future in sensory/consumer research: … evolving to a better science. *Food Quality and Preference,* 27, 208-214. http://dx.doi.org/10.1016/j.foodqual.2012.03.002

Min, Weiqing., Jiang, S., Wang, S., Sang, J. & Mei, S. (2017). A delicious recipe analysis framework for exploring multi-modal recipes with various attributes. *Proceedings of the 25th ACM international conference on Multimedia.*

Møller, P. (2013). Gastrophysics in the brain and body. Flavour, 2:8. https://doi.org/10.1186/2044-7248-2-8.

Murray, D. W. & O'Neill, A. (2012). Craft beer: penetrating a niche market. *British Food Journal,*144,7, 899-909.

Oliveira M. & Falconi, D. (2018). The evolution of craft beer industry in Brazil. *Journal of Economics and Business, 4, 618-626.* https://doi.org/10.31014/aior.1992.01.04.55

Pettigrew, S., & Charters, S. (2006). Consumers' expectations of food and alcohol pairing. *British Food Journal,* 108:3, 169-180. https://doi.org/10.1108/00070700610650990.

Paulsen, M., Rognsa, G. H. & Hersleth, M. (2015). Consumer perception of food-beverage pairings: The influence of unity in variety and balance. *International Journal of Gastronomy and Food Science,* 2, 83-92. http://dx.doi.org/10.1016/j.ijgfs.2014.12.003.

Rozin, P. (1996). Sociocultural influences on human food selection. In E. D. Capaldi (Ed.), Why we eat what we eat: The psychology of eating (pp. 233–263). *American Psychological Association.* https://doi.org/10.1037/10291-009

Rozin, P. (2002) Human food intake and choice: Biological, Psychological, and Cultural Perspectives. In H. Anderson, J. Blundell, & M. Chiva (eds.) *Food selection: From genes to culture*. (pp. 7-24). Paris: Danone Institute.

Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion,* 4, 77–101.

Rune, J. B., Münchow, M. & Perez-Cueto, F. J. A. (2021). Systematic review of methods used for pairing with coffee, tea, wine, and beer. *Beverages,* 7,40. https://doi.org/10.3390/beverages7020040.

Sánchez-Cañizares, S. M. & López-Guzmán, T. (2012). Gastronomy as a tourism resource: profile of the culinary tourist. *Current issues in Tourism,* 229-245. http://dx.doi.org/10.1080/13683500.2011.589895

Saldaña, E. (2019). Use of sensory analysis and social media for product development driven by consumers: a case-study for smoked bacon. Thesis for PhD Degree. https://doi.org/10.13140/RG.2.2.10823.44969

Samavati, V., Emam-Djomeh, Z., Mehdinia, A., Mohammadifar, M. A. & Omid, M. (2012). Effect of Composition on reléase of aroma compounds. *Iranian Journal of Chemistry and Chemical Engineering (IJCCE),* 31,3.

Scander, H. (2019). Food and beverage combinations: Sommeliers' perspectives and consumer patterns in Sweden. Doctoral Thesis.

Scander, H., Monteagudo, C., Nilsen, B., Tellström, R. & Yngve, A. (2018). Food and beverage dinner combinations, patterns among Swedish adults. *International Journal of Gastronomy and Food Science,* 14, 20-26. https://doi.org/10.1016/j.ijgfs.2018.08.003.

Sester, C., Deroy, O., Sutan, A., Galia, F., Desmarchelier, J-F., Valentin, D. & Dacremont, C. (2013). “Having a drink in a bar”: An immersive approach to explore the effects of context on drink choice. *Food Quality and Preference,* 28, 23-31. https://doi.org/10.1016/j.foodqual.2012.07.006.

Simas, T., Ficek, M., Diaz-Guilera, A., Obrador, P., & Rodriguez, P. R. (2017). Food-bridging: a new network construction to unveil the principles of cooking. *Frontiers in ICT* https://doi.org/10.3389/fict.2017.00014

Simeone, M. & Scarpato, D. (2020). Sustainable Consumption: How does social media affect food choices?. *Journal of Cleaner Production,* 277, 124036. https://doi.org/10.1016/j.jclepro.2020.124036.

Spence, CH. (2020). Food and beverage flavour pairing: Acritical review of the literature. *Food Research International,* 133, 109124. https://doi.org/10.1016/j.foodres.2020.109124

Spence, CH. (2018). Why is piquant/spicy food so popular?. *International Journal of Gastronomy and Food Science,* 12, 16-21. https://doi.org/10.1016/j.ijgfs.2018.04.002.

Spence, CH., Wang, Q. J. & Youssef, J. (2017). Pairing flavours and the temporal order of tasting. *Flavour,* 6,4. https://doi.org/10.1186/s13411-017-0053-0

Traynor, M. P., Burke, R., O'Sullivan, M. G., Hannon, J. A. & Barry-Ryan, C. (2013). Sensory and chemical interactions of food pairings (basmati rice, bacon and extra virgin olive oil) with banana. *Food Research International,* 54, 569-577. https://doi.org/10.1016/j.foodres.2013.07.050.

Twitter (2021). *About.* Available at: https://about.twitter.com Accessed 13 September 2021.

Varshney, K.R., Varshney, L., Wang, J., & Myers, D. (2013). Flavor pairing in Medieval European cuisine: A study in cooking with dirty data. arXiv:1307.7982.

Vidal, L., Ares, G., Machín, L., & Jaeger, S. R. (2015). Using Twitter data for food-related consumer research: A case study on what people say when tweeting about different eating situations. Food Quality and Preference, 45, 58–69. http://dx.doi.org/10.1016/j.foodqual.2015.05.006.

Wright, J. (2010). Creating and formulating flavours. In Taylor, A.J. & Linforth, R. S. (eds.) *Food Flavour Technology.* Blackwell Publishing Ltd.

Zhang, C., Yue, Z., Zhou, Q. & Ma, S. (2019). Using social media to explore regional cuisine preferences in China. *Online Information Review,* 43:7, 1098-1114. https://doi.org/10.1108/OIR-08-2018-0244

Appendix

Appendix 1.

Chapter 1. Supplementary Table 1. Boolean search for study 1. Beer flavor pairing in social media

(“beer” OR “beers”) AND (“flavor” OR “taste” OR “drink” OR to drink” OR “acid" OR "bitter" OR "cranberry" OR "acorn" OR "coffee" OR "cinnamon" OR "caramel" OR "cherry" OR "chili" OR "chocolate" OR "coconut" OR "sweet" OR "peach" OR "raspberry" OR "strawberry" OR "fruity" OR "fruits" OR "hibiscus" OR "ginger" OR "yeast" OR "lime" OR "malt" OR "mango" OR "butter" OR "apple" OR "passion fruit" OR "yellow peach" OR "metallic" OR "honey" OR "berry" OR "orange" OR "pineapple" OR "banana" (two words: “plátano” for Mexico and “banana” for Argentina) OR "cheese" OR "licorice" OR "watermelon" OR "tamarind" OR "tequila" OR "toasted" OR "grapefruit" (two words: “toronja” for Mexico and “pomelo” for Argentina) OR "wheat" OR "grape" OR "vanilla" OR "vinegar" OR "acetone" OR "plum" OR "woody" OR "pepper" OR "raisins" OR "blackberry" OR "floral" OR "flowers" OR "hop" OR "pecan" OR “pecans" OR "anise" OR "mezcal" OR "wine" OR "agave" OR "peanut" OR "peanuts" (two words: “cacahuate” for Mexico and “maní” for Argentina) OR "oats").

Appendix 2.

Chapter 1. Supplementary Table 2. Boolean search for study 2. Flavor pairing per country

"coffee" NEAR/9 ("acid" OR "bitter" OR "cranberry" OR "acorn" OR "cinnamon" OR "caramel" OR "cherry" OR "chili" OR "chocolate" OR "coconut" OR "sweet" OR "peach" OR "raspberry" OR "strawberry" OR "fruity" OR "fruits" OR "hibiscus" OR "ginger" OR "yeast" OR "lime" OR "malt" OR "mango" OR "butter" OR "apple" OR "passion fruit" OR "yellow peach" OR "metallic" OR "honey" OR "berry" OR "orange" OR "pineapple" OR "banana" (two words: “plátano” for Mexico and “banana” for Argentina) OR "cheese" OR "licorice" OR "watermelon" OR "tamarind" OR "tequila" OR "toasted" OR "grapefruit” (two words: “toronja” for Mexico and “pomelo” for Argentina) OR "wheat" OR "grape" OR "vanilla" OR "vinegar" OR "acetone" OR "plum" OR "woody" OR "pepper" OR "raisins" OR "blackberry" OR "floral" OR "flowers" OR "hop" OR "pecan" OR "pecans" OR "anise" OR "mezcal" OR "wine" OR "agave" OR "peanut" OR "peanuts" (two words: “cacahuate” for Mexico and “maní” for Argentina) OR "oats") AND ("flavor" OR "taste" OR "drink" OR "to drink" OR "flavors" OR "combine" OR "combination" OR "food" OR "foods" OR "eat")

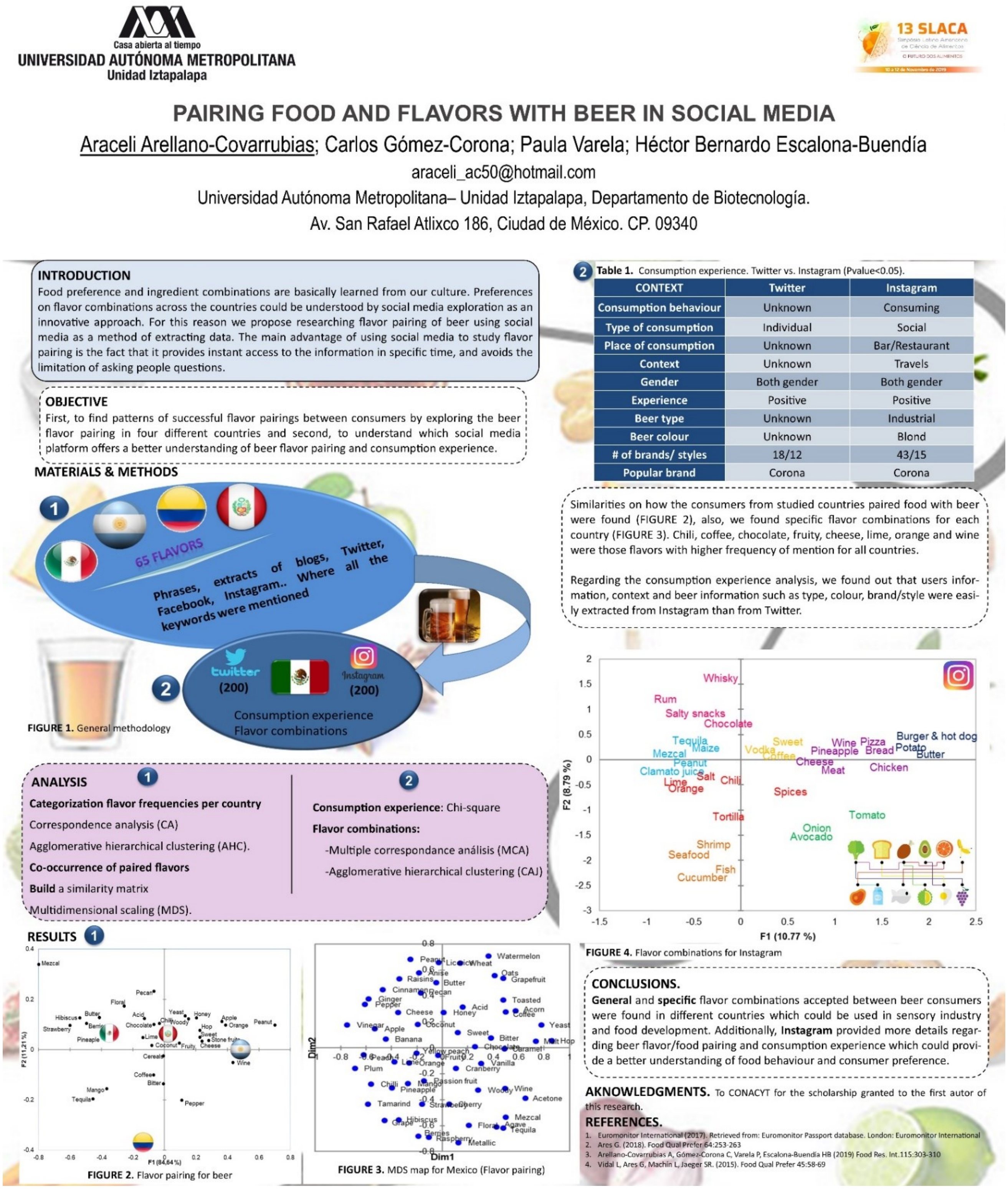
Appendix 3.

Chapter 1. Supplementary Table 3. Flavor clusters for Mexico, Argentina, Colombia, and Peru obtained from the hierarchical cluster analysis

	Clusters											
Country	1	2	3	4	5	6	7	8	9	10	11	12
Mexico	Acid	Acorn	Cinnamon	Cherry	Chili	Peach	Strawberry	Yeast	Butter	Tequila		
	Bitter	Coffee	Coconut	Raspberry	Hibiscus	Plum	Lime	Malt	Licorice	Acetone		
	Cranberry	Watermelon	Ginger	Metallic	Tamarind		Mango	Hop	Wheat	Mezcal		
	Caramel	Toasted	Banana	Berries	Grape		Passion fruit		Pecan	Wine		
	Chocolate	Grapefruit	Cheese	Floral			Yellow peach		Anise	Agave		<
	Sweet	Oats	Apple	Woody			Orange		Peanut			
	Fruity		Vinegar				Pineapple					
	Honey		Pepper									
	Vanilla		Raisins									
Argentina	Acid	Bitter	Cranberry	Acorn	Coffee	Cinnamon	Caramel	Chili	Peach	Raspberry	Wheat	
	Licorice	Chocolate	Coconut	Yeast	Malt	Hibiscus	Cherry	Tequila	Strawberry	Fruity	Grape	
	Watermelon	Sweet	Butter	Wine	Metallic	Ginger	Pineapple	Floral	Mango	Lime	Raisins	
	Vinegar	Honey	Banana		Toasted	Pepper	Tamarind	Mezcal	Yellow- peach	Passion fruit	Oats	
	Acetone	Cheese	Vanilla		Hop			Woody	Plum	Orange		
	Grapefruit	Pecan	Berries		Agave					Apple		
			Peanut							Anise		
Colombia	Acid	Bitter	Cranberry	Coffee	Cinnamon	Cherry	Chili	Coconut	Peach	Hibiscus	Malt	Honey
	Caramel	Mango	Chocolate	Cheese	Vinegar	Raspberry	Tequila	Ginger	Strawberry	Metallic	Licorice	Wheat
	Sweet	Orange	Fruity	Toasted	Pepper	Banana	Mezcal	Lime	Passion fruit	Tamarind	Acetone	Agave
	Yeast	Watermelon		Grapefruit	Raisins		Wine	Butter	Yellow peach		Hop	Oats
		Grape		Floral	Pecan			Apple	Pineapple			
				Woody	Anise			Vanilla	Plum			
								Peanut	Berries			
Peru	Acid	Cranberry	Coffee	Cinnamon	Cherry	Chili	Coconut	Peach	Raspberry	Butter		
	Bitter	Chocolate	Metallic	Ginger	Strawberry	Tequila	Yellow peach	Acetone	Hibiscus	Honey		
	Caramel	Fruity	Watermelon	Yeast	Mango	Mezcal	Wheat	Wine	Malt	Cheese		
	Sweet	Banana	Toasted	Lime	Passion-fruit		Vanilla		Tamarind	Licorice		
	Berries		Grapefruit	Apple	Orange		Pecan		Floral	Raisins		
	Hop		Oats	Vinegar	Pineapple					Agave		
	Anise			Pepper	Grape					Peanut		
	Woody				Plum							

Appendix 4.

Chapter 2. Poster presented at the 13 SLACA Simposio Latino Americano de Ciencia de Alimentos, Campinas-Sao Paulo, Brazil, 2019.



Appendix 5.

Chapter 3. Supplementary material 1. Foods with high frequency to be paired with beer

Foods extracted from study 1 and 2 of Arellano et al. (2019)		Foods from Instagram and Twitter
Study 1	Study 2	
Acid	Anise	**Avocado**
Apple	Acorn	**Bread**
Berries	Agave	Burger & hot dog
Bitter	**Apple**	**Butter**
Butter	Banana	**Cheese**
Cereals	**Berries**	**Chicken**
Cheese	Bitter	**Chili**
Chili	**Butter**	**Chocolate**
Chocolate	Caramel	Tomato
Coconut	**Chocolate**	**Coffee**
Coffee	Cinnamon	**Cucumber**
Floral	Coffee	**Fish**
Fruity	**Ginger**	**Lime**
Hibiscus	Grape	Maize
Honey	Grapefruit	Mezcal
Hop	**Hibiscus**	**Oats**
Lime	**Lime**	**Onion**
Mango	**Mango**	**Orange**
Mezcal	Mezcal	**Peanut**
Orange	**Oats**	**Pineapple**
Peanuts	**Orange**	**Pizza**
Pecan	Passion fruit	**Potato**
Pepper	Peach	**Red meat**
Pineapple	**Peanuts**	Rum
Stone fruits	**Pepper**	Salt
Strawberry	**Pineapple**	**Salty snacks**
Sweet	Plum	Seafood
Tequila	Raspberry	**Shrimp**
Wine	Tequila	**Spices**
Woody	Toasted	Sweet
Yeast	Vanilla	Tequila
	Yeast	**Tomato**
	Yellow peach	**Tortillas**
		Vodka
		Whisky
		Wine

The foods were selected due to a high frequency of mentions (in the case of Twitter and Instagram) or when the foods were mentioned at least in two of the three studies (study 1 and 2 from Arellano et al. (2019), and the information from Instagram and Twitter). Bold letters indicate the selected foods.

Appendix 6.

Chapter 3. Supplementary material 2. Food and beverage paper cards design.

Appendix 7.

Chapter 3. Supplementary material 3. PANOVA results of GPA

Source	DF	Sum of squares	Mean squares	F	Pr > F
Residuals after scaling	6732	5214402	775		
Scaling	99	134718	1361	1.8	< 0.0001
Residuals after rotation	6831	5349120	783		
Rotation	99	833184	8416	10.9	< 0.0001
Residuals after translation	6930	6182304	892		
Translation	198	1362674	6882	8.9	< 0.0001
Corrected total	7128	7544978	1058		

UNIVERSIDAD AUTÓNOMA METROPOLITANA

Casa abierta al tiempo

ACTA DE DISERTACIÓN PÚBLICA

No. 00251

Matrícula: 2171802209

Maridaje de alimentos y bebidas desde una perspectiva sensorial y cultural

Con base en la Legislación de la Universidad Autónoma Metropolitana, en la Ciudad de México se presentaron a las 8:00 horas del día 18 del mes de noviembre del año 2021 POR VÍA REMOTA ELECTRÓNICA, los suscritos miembros del jurado designado por la Comisión del Posgrado:

DR. GASTON ARES DEVINCENZI
DRA. LETICIA VIDAL BERRIEL
DR. FRANCISCO JOSE FERNANDEZ PERRINO
DR. CARLOS GOMEZ CORONA

Bajo la Presidencia del primero y con carácter de Secretario el último, se reunieron a la presentación de la Disertación Pública cuya denominación aparece al margen, para la obtención del grado de:

DOCTORA EN BIOTECNOLOGIA

DE: ARACELI ARELLANO COVARRUBIAS

y de acuerdo con el artículo 78 fracción IV del Reglamento de Estudios Superiores de la Universidad Autónoma Metropolitana, los miembros del jurado resolvieron:

APROBAR

Acto continuo, el presidente del jurado comunicó a la interesada el resultado de la evaluación y, en caso aprobatorio, le fue tomada la protesta.

UNIVERSIDAD AUTÓNOMA METROPOLITANA
Casa abierta al tiempo
DIRECCIÓN DE SISTEMAS ESCOLARES

ARACELI ARELLANO COVARRUBIAS
ALUMNA

REVISÓ

MTRA. ROSALIA SERRANO DE LA PAZ
DIRECTORA DE SISTEMAS ESCOLARES

DIRECTORA DE LA DIVISIÓN DE CBS

DRA. SARA LUCIA CAMARGO RICALDE

PRESIDENTE

DR. GASTON ARES DEVINCENZI

VOCAL

DRA. LETICIA VIDAL BERRIEL

VOCAL

DR. FRANCISCO JOSE FERNANDEZ PERRINO

SECRETARIO

DR. CARLOS GOMEZ CORONA