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Consumer sensitivity and Freshness Evaluation of Bakery Products

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Consumer Sensitivity and Freshness Evaluation of Bakery Products

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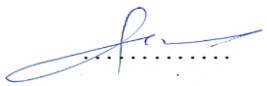
Dr. Samer Mudalal/ Supervisor	
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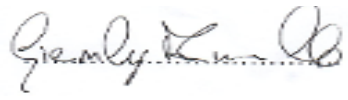
Prof. Gianluigi Mauriello/ External Examiner	
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Dedication

First of all, I thank God " Allah" who granted me his blessing to continue my higher education and move forward in my scientific career

and accomplish this research

Every challenging work needs self-efforts as well as guidance of elders

especially those who were close to our heart

My humble effort I dedicate to my sweet and loving

Father, mother, sisters &brothers

For your patience, love, friendship &making everything possible

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Of course, many thanks for Oropan company for providing me *focaccia* samples required for consumer test.

Table of Contents

List of Figures

List of Tables

Consumer sensitivity and Freshness Evaluation of Bakery Products

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Abstract

Focaccia is a typical bakery product in Italy, which is highly appreciated for its sensory characteristics and has its own market. Its quality deterioration during storage is caused chiefly by various deteriorative events which include the loss of crispness linked to high water activity, starch retrogradation and lipid oxidation. The loss of freshness in bakery products negatively affects consumer's liking and the product's quality. The freshness perception of a food during its shelf life depends on both the sensory properties of the food and the consumer's ability to perceive a sensory deterioration. Consumers differ in their abilities to perceive tastes and textures, and these perception differences may lead to different preferences. Sensory methods can be used to understand individual sensitivity of consumers. The main purpose of this research is to evaluate consumer perception of *focaccia* samples stored at different times and to explore whether there is an association between consumer sensitivity and the perception of *focaccia* samples. *Focaccia* with two different toppings (tomato &olives (F1), and frozen onion with oregano (F2)) were considered in this research. All samples were stored for 7, 15, 30, and 60 days at 20ºC. Consumer sensitivity to taste, odor and texture were evaluated by using PROP status test, odor pens test, and hardness test, respectively. Weibull distribution was used to describe the rejection function. CATA method was used to determine sensory attributes of *focaccia* samples. Nighty-nine consumers participated in the consumer test. Consumers were asked to eat each sample of *focaccia* and to answer the question:" Would you normally consume/buy *focaccia*? Yes or No?". They were asked also to choose the most suitable attributes that can describe the samples and to evaluate their liking by using 10cm scale anchored from "the most unpleasant imaginable" to "the most pleasant imaginable". From survival analysis, it was observed that the acceptance percentage for samples stored for 60 days was slightly higher for samples F2 (50%) compared to (47%) for samples F1. The shelf life was estimated as the storage time that corresponded to 50% consumers acceptance in 58 ±6 d, and 61±5 d, respectively for samples F1 and F2. For sample F1, CATA questions results showed that there are significant differences for both negative attributes (stale, dry tomato, hard,

raw dough) and positive attributes (soft, typical *focaccia* flavor, sweet tomato, fresh tomato). In the same way, for sample F2, CATA questions results showed that there are significant differences in terms of both negative (stale, hard, onion taste) and positive (soft, pungent onion taste) attributes. For both types of samples, it was also noted that fresh samples were liked as the as those stored for 60 days. Our findings also showed that there is no significant association between liking scores of *focaccia* and socio-demographic variables (age and gender). We recommend that the current study should be followed up with larger number of consumers. Future studies should also assess participants' psychological and personality traits.

Keywords: bakery products, shelf life, sensory attributes, Check-all-that-apply (CATA), texture sensitivity, odor sensitivity, PROP sensitivity.

1.Introduction

It is essential for both food researchers and manufacturers to comprehend how consumers perceive food with a view to make a product which matches consumers' acceptability and anticipation. (Guinard et al., 2001). Maintain the stability of food products over the time is considered one of the most essential aspects of product quality. So based on this fact, food companies should design food products that meets consumers' anticipations (Subramaniam., 2016). According to IFST (1993), shelf life is defined as the duration of time which the food product will (i) kept safe to be used (ii) should retain its desired sensory, chemical, physical and microbiological attributes; (iii) adhere to any label declaration of nutritional data. However, a retailer views a shelf life of a product as an approach to increase sales potential. The termination of a products' shelf life is set by the point in time in which the product is undesirable or unsafe to the target consumer. (Man, 2002).

Sensory professionals can use various techniques to determine shelf life. Measurements from professional sensory testing can lead to consumer rejection. This in turn would propose that the product would not be consumed or purchased (Smith et al., 2010). Sensory methods can be used to understand individual sensitivity of consumers. The freshness perception of a food during its shelf life depends on both the sensory properties of the food and the consumer's ability to perceive a sensory deterioration. Consumers differ in their abilities to perceive tastes and textures, and these perception differences may lead to variable preferences. Therefore, it is important to explore the effect of consumer's sensitivity before considering product results (Dinehart et al., 2006).

1.1. Overview on *Focaccia* Bread

The word "*focaccia*" derives from the Latin *focus*, meaning fireplace. In the Middle Ages, *focaccia* was considered a poor food, made with remnants of the dough destined to bread making and baked to test the temperature of wood-fired ovens before introducing bread. Once made, it was consumed by bread makers. Today, *focaccia* is highly appreciated for its sensory properties and has its own market. It is usually consumed, still hot, as a "street food" immediately after its production. If not consumed very fresh, it loses flavor and its consistency tends to harden (Pasqualone et al., 2011).

Focaccia is made of a few simple ingredients- flour, water, fatty substances (oil or lard), yeast, and salt-but a myriad of nuanced differences are obtainable by topping it, prior to cooking with fresh tomato, potatoes, onions, olives, cheese, or flavoring it with herbs (sage, rosemary, oregano, etc.).it usually appears as a single layered, oily, circular flat bread, and variously topped (Pasqualone et al., 2011).

Especially in its "red version", topped with tomato, *focaccia* may appear similar to Italian pizza, but actually there are many differences between these two food categories regarding both the ingredients and the way in which they are consumed. *Focaccia* is characterized by a high content of fatty substances in the dough, whereas in pizza only a very small amount of oil is added on the surface. This contributes to a different flavor and makes the consistency of these two products different. Furthermore, *focaccia* is generally thicker and, above all, less humid than pizza. The latter, being always topped with mozzarella cheese, is characterized by the presence of some liquid on the surface (Pasqualone et al., 2011).

These characteristics make a piece of *focaccia* a perfect street food to be eaten as a snack or an appetizer, whereas in Italy pizza is usually consumed while sitting at a table, using dishes, typically at dinner or, in recent years, also at lunch (Pasqualone et al., 2011).

1.1.1. The Basic Ingredients of *Focaccia*

Flour

To obtain a good yield and a high specific volume, flour characteristics have to fulfill the requirements of the processing technology of the *focaccia*. The major issue is the overall duration of the process. In the past, only the sourdough-based prolonged process was performed. Today, to accomplish faster production rhythms, fresh compress baker's yeast is used in the majority of bakeries (Pasqualone et al., 2011).

Fatty Substances

Many fatty substances can be used in bakery: lard, butter, margarines, refined seed oils, olive oil, olive-pomace oil and hydrogenated vegetable oils. Their content may range from 5 -15% for some bread substitutes, such as breadsticks, crackers, and *focaccia*, to 20-30% in biscuits and cakes. The

choice of the most suitable lipid is closely associated with the desired dough workability, the product's rheological and sensory properties, shelf life, and consumer needs (Pasqualone et al., 2011).

Olive oil, notably extra-virgin olive oil, is an essential ingredient in the preparation of many types of *focaccia*. It makes *focaccia* pleasant and palatable, and it provides a characteristic smell and taste (Pasqualone et al., 2011)

1.2. Freshness of Bakery Products

Freshness is considered a holistic property of a food product, which it can indicates how lately manufactures, or cropped food presently is, or how much time it can be preserved, or it can be the inverse of musty. The sensory characteristics of foods have a strong influence on freshness perception by the consumer. However, these attributes are not readily recognized and characterized since they will differ greatly among various kinds of goods.

Heenan *et al.* (2009) have conducted two independent consumer studies. In the first one, it was requested from consumers to estimate product freshness depending on texture, flavor, and appearance. However, in the second study, the consumer just has to estimate odor. At the end of the study, it was observed that sensory properties sensed to be fresh in one food item was not necessarily to be fresh in a second item. Comparison between consumer and sensory vocabulary also displayed a fixed texture, taste and appearance evidence that consumers linked them with product freshness which was utilized to distinguish the same food items cognitively.

A former study was performed to illustrate the significance of freshness for the consumer and rapport to sensory and non-sensory attributes of apples. It was found by the end of this study that freshness was very-well clarified through crispness, juiciness, and taste. It was also observed that freshness was influenced by gender, apple intake and participant's age (Péneau *et al.*, 2006).

Lennernäs et al. (1997) carried out a baseline survey to explore the factors that have a great impact on food choices and preferences. It was concluded that food choices and preference were highly influenced by freshness, which affected mostly by women when compared to men.

Freshness estimation of different types of cakes was conducted by Heenan *et al.* (2010). In that research, it was indicated that the perceived freshness was highly affected by time of baking, and type of fat and sweetener. All volunteers concurred that the freshest cakes were assessed on the same day of baking, whereas the least fresh cakes were assessed after fifteen days of baking.

1.3. Analytical strategies for the evaluation of freshness of bakery products

The sensory quality of food products is believed to be an essential property and a crucial criterion for the choice or rejection of the food product. Bakery products such as *focaccia,* buns, muffins and bagels like many processed foods, are subject to physical, chemical and microbiological spoilage which are the main characteristics linked to consumer rejection. Their varying levels of moisture content and water activity cause these characteristics to deteriorate. High moisture content leads to microbiological spoilage by bacteria, yeast and molds making the product unappealing to consumer (Smith et al., 2010). Nowadays, consumers draw the attention toward quality because of risks and health problems related to unsafe products and unknown source. During storage and progress of shelf-life, staling can happen in baked products and can trigger deterioration of nutritional, sanitary, sensory properties and freshness.

Therefore, consumer acceptability for baked products reduces and thus, give rise to low sales, and returned unsold goods, which can result in a severe damage and economic burden. As a result, the measurement of baked food staling during storage is an important step of quality assurance program, which aims to monitor freshness. The next paragraphs will focus on macroscopic and molecular analytical methods employed to control intrinsic dimensions of product quality, which contribute to consumer impression and acceptance. These techniques tend to supplement each other, and provide together a comprehensive evaluation of defects in the final product

1.3.1. Macroscopic Techniques

Macroscopic or macro-analytical methods are known as an immediate evaluation of clear characteristics, which can help in discovering obvious and/or apparent defects. This is typical consumer macroscopic examination. Instrumental analysis and sensory evaluation of clear properties are the most used ones in baked products to examine their quality. These techniques include: (i) instrumental measurement of texture; (ii) instrument measurement of color; (iii) sensory evaluation **(See section 1.4.).**

Instrumental measurement of texture

According to Szczesniak (2002), the texture is defined as "the sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the sense of vision, hearing, touch and kinesthetic". The main purpose of instrumental measurements is for example to evaluate the mechanical behavior of sponge cake by using tests mimicking mastication and handling, and in that way, elastic recovery tests and texture profile analysis (TPA) have been often employed to examine this purpose.

Through TPA test, a broad range of food texture characteristics, such as springiness, hardness, adhesiveness, cohesiveness, wateriness, resiliency, chewiness, sliminess, and gumminess, can be identified (Fiszman et al., 2013). All these parameters are directly deduced from the force-distance curve, which is the data obtained from TPA. They depend on the used recipe and the freshness of cakes.

Research articles showed that TPA is an effective technique in observing cake freshness, however, it may not be the best option for each analytical condition because it is slow and expensive, need trained operators and time consuming (Nhouchi et al., 2018).

Instrumental measurement of color

Color is an essential standard of the quality of baked products. It informs about the: (i) freshness; (ii) alterations of bakery; and (iii) baking kinetics. During baking, Maillard and caramelization and Maillard reactions may occur giving a caramel-like color and brown color, respectively. The storage of baked products may also change intensity of color could change due to spoilage oxidation. In

some conditions, individuals are unable to examine color alterations because of variations and to subjectivity of color perception by humans. Therefore, instrumental techniques should be utilized to give more accurate and more elaborated data. In this way, the most utilized instrument for cake color measurement in research and industry was the colorimeter (Fiszman, Sanz, & Salvador, 2013).

Color determination is a useful measurement, which contributes positively to the success of formulation and monitoring baking and freshness during storage. However, this parameter depends on several factors such ingredient-pigmentation, baking temperature, and so on, leading to an ambiguous interpretation of the results (Nhouchi et al., 2018).

1.3.2. Molecular Analytical Techniques

Even though molecular analysis techniques are considered important, however, they have drawn a small attention in comparison to macroscopic and microscopic analyses. The main objective of these methods is to: i) comprehend how matter responds to light; ii) find one-to-one correspondence between internal and the spectra structures of matrix; iii) categories materials based on their reaction to light. In this case, taking a photo is not necessary, just spectra would be enough. These methods rely on spectroscopy measurements which point out to spectroscopic methods in a various electromagnetic radiation spectrum (ultraviolet (UV), visible (VIS) and infrared (IR)). Despite the variances in instrumentation, all spectroscopic methods have common features. Recently, they have been employed to check safety of different baked products (see **Table 1.1**) (Nhouchi et al., 2018).

Table 1.1 Summary overview of molecular techniques used for the checking the freshness and quality of baked products.

Analytical Techniques	**Objectives**
Frontface fluorescence spectroscopy	- Monitoring the formation of neoformed products in dynamic and nearly non-invasive way during baking process. - Evaluation of cake ageing during storage.
Infrared spectroscopy	- Monitoring batter development during mixing. - Understanding conformational changes related to batter development. - Investigation of fraud and adulteration during sponge cake making. - Evaluation of lipid oxidation in cakes during storage.

1.4. Sensory Analysis

The sensory evaluation is a scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of food products or food materials as they are perceived by the sight, smell, taste, touch and hearing. The sensory methods that can be used to characterize a product are in described in detail in the following section.

1.4.1. Descriptive Sensory Analysis

Descriptive sensory analyses are the most sophisticated tools in the arsenal of the sensory scientist. These techniques allow the sensory scientist to obtain complete sensory descriptions of products, to identify underlying ingredient and process variables, and/or to determine which sensory attributes are important to acceptance. A generic descriptive analysis would usually have between 8 and 12 panelists that would have been trained, with the use of reference standards, to understand and agree on the meaning of the attributes used. They would usually use a quantitative scale for intensity which allows the data to be statistically analyzed. These panelists would not be asked for their hedonic responses to the products. Usually, descriptive techniques produce objective descriptions of products in terms of the perceived sensory attributes. Depending on the specific technique used, the description can be more or less objective, as well as qualitative or quantitative.

In the following section, we will review the major approaches and philosophies of descriptive analysis techniques that can be used to characterize and describe a product.

1.4.1.1. Flavor Profile ®

Flavor profiling (FP) is a consensus technique. The vocabulary used to describe the product and the product evaluation itself is achieved by reaching agreement among the panel members. The FP considers the overall flavor and the individual detectable flavor components of a food system. The profile describes the overall flavor and the flavor notes and estimates the intensity of these descriptors and the amplitude (overall impression). The technique provides a tabulation of the perceived flavors, their intensities, their order of perception, their aftertastes, and their overall impression (amplitude). If the panelists are trained appropriately this tabulation is reproducible (Keane., 1992)

1.4.1.2. Quantitive Descriptive Analysis ®

Quantitative Descriptive Analysis (QDA)® is a behavioral sensory evaluation approach that uses descriptive panels to measure a product's sensory characteristics. Panel members use their senses to identify perceived similarities and differences in products and articulate those perceptions in their own words (Stone et al. 1974).

1.4.1.3. Texture Profile ®

The Texture Profile (TP) uses a standardized terminology to describe the textural characteristics of any product. Specific characteristics are described by both their physical and sensory aspects. Product-specific terms to be employed are chosen from the standardized terminology to describe the texture of a specific product. Definitions and order of appearance of the terms are decided through consensus by the TP panelists. Rating scales associated with the textural terms are always standardized (Civille et al., 1975).\

1.4.1.4. Sensory Spectrum ®

The Sensory Spectrum procedure is a further expansion of descriptive analysis techniques. The unique characteristic of the Spectrum approach is that panelists do not generate a panel-specific vocabulary to describe sensory attributes of products, but that they use a standardized lexicon of terms (Civille &Lyon, 1996).The language used to describe a particular product is chosen a priori and remains the same for all products within a category over time. Additionally, the scales are standardized and anchored with multiple reference points.

1.4.2. Preference Mapping Methods

Preference mapping methods attempt to associate consumer preference ratings to perceived sensory attributes of the product in order to explain how the sensory characteristics of the product affect consumer liking (Arditti 1997; Van kleef et al. 2006).Although preference mapping is one of the most known techniques of marketing research (Van kleef et al. 2006), it has been assumed to have several limitations (ten Kleij & Musters 2003; Krishnamurthy et al. 2007). One of these limitations is that it claims that trained panel perceive the products in the same way as consumers do. In these methods, consumers are only asked how much they like the product, and thus, information about how they perceive the sensory attributes of the product is not obtained. Therefore, sensory information is gathered from a trained assessors (Faye et al. 2006). On the otherhand, trained panel could characterize the product in a distinct way or take into consideration characteristics that may be irrelevant for consumers (ten Kleij & Musters 2003).

In order to obtain data about how consumers perceive the sensory attributes of a food product, consumer researches usually involve questions about the product's sensory properties (Meilgaardet al. 2006). Attribute liking questions and just-about-right (JAR) scales are some of the main used methods to gather information about consumers' perception of the sensory properties of a product (Popper et al. 2004). Another alternative is the use of check-all-that-apply questions (CATA).

1.4.2.1. Check-All-That-Apply (CATA)

A check-all-that-apply (CATA) approach is a multiple-choice questionnaire in which participants are presented with a roster of phrases or word and required to choose all the choices they believe

suitable. This question format has been extensively utilized in marketing research and is well-known since it reduces respondent answer burden (Driesener and Romaniuk, 2006; Rasinki et al., 1994; Smyth et al., 2006).

CATA questions have been newly used in consumer and sensory science in order to get information about consumers' perception of products (Adams et al., 2007). Although the method has been formerly used with a trained panel (Campo et al., 2010; Le Fur et al., 2003; McCloskey et al., 1996), and its growing popularity has increased for product sensory characterization with consumers (Varela and Ares, 2012).

In this method, consumers are given with a group of products and a CATA question to describe them. Consumers are required to try the products and to answer the CATA question by choosing all the terms that they believe suitable to characterize each of the samples, without any constraint on the number of properties that can be chosen. The roster of phrases or words in the CATA question usually include exclusively sensory properties of the product (Figure 1.1a), however, it can also involve hedonic expressions, as well as expressions associated with non-sensory properties, such as emotions, product positioning and usage occasions (Figure 1.1b) (Ares and Jaeger, 2013; Parente et al. , 2011; Piqueras-Fiszman and Jaeger, 2014; Plaehn, 2012). Choosing terms and expressions from a roster has been suggested to be a simple and conjectural assignment for consumers, which needs less cognitive exertion than other attribute-based approaches such as intensity or just-about-right scales (Adams et al., 2007). Also, it has also been confirmed that they result in a more automatic valuation than forced-choice questions or scales (Smyth et al., 2006).

The application of CATA questions has been confirmed to be a rapid alternate approach to obtain information about consumer perception of the sensory characteristics of food products, providing identical information to that gathered using descriptive analysis with trained panel (Ares et al., 2010; Bruzzone et al., 2012; Dooley et al., 2010). In a research performed by Jaeger et al. (2013) concluded that conclusions and product configurations related to differences and similarities among samples of different product classes were the same during sessions. Thus, even though being simple and rapid for consumers, CATA answers are reliable. Overall, CATA questions can be used in investigating consumer perception in both industrial and academic settings.

Figure 1.1 Examples of CATA questions including: (a) sensory properties(b) both non-sensory and sensory properties

1.5. Individual Differences in Sensory Perception

There are individual variations in both aroma and taste perception; some of them are genetical differences whereas the others are considered phenotypical differences. Besides, aroma and taste sensitivity eliminate with age (Methven et al., 2012). Therefore, it is fundamental to take these variations into our comprehension of how the consumer perceives the flavor.

1.5.1. Taste Sensitivity

The most marked known variation in taste perception id the phenotypical variation in the capability to taste thiourea category that exists in 6-n-proplthiourcail (PROP). This variation is caused by genetic variations in TAS2R38 bitter receptor; however, it is also an indication for overall taste sensitivity. Last literature reviews indicate that this is due to a polymorphism of the gustin gene which influences fungiform papilla maintenance and growth. Some individuals with the AA gustin genotype create more taste cells, thus they are more sensitive to PROP and to broad range of taste stimuli (Melis et al., 2013)

There is an increased evidence proposes that individual variations in perceived 6-n-propylthiouracil (PROP) intensity may slightly clarify individual variations in texture perception. Hayes and Duffy (2007) noted that perceived PROP intensity was significantly correlated with creaminess ratings of milk, heavy cream, and water. In 2004, Pickering and his colleagues found that supertasters perceived a high astringency in wine. In another research performed by Pickering and Robert (2006), it was showed that the supertasters did not perceive a high astringency of wine, however, they found that supertasters perceived an increased intensity for wine sensory attributes including; smoothness after expectoration, particulates after expectoration, mouthcoating and grippy/adhesive. Tepper and Nurse (1997) explored that supertasters and medium tasters were able to differentiate between 10% fat and 40% fat Italian salad dressings, while non-tasters were not. Bakke and Vickers (2008) have found that supertasters perceived higher roughness, sweetness, and bitterness intensities and were better able to differentiate roughness variations of bread. Yackinous and Guinard (2001), however, found that taster status was not linked to fattiness perception in mashed potatoes, chocolate drink, vanilla pudding, mashed potato, and potato chips, whilst, they noticed that supertasters show greater sensitivity to stimulation on the medial tongue. De Wijk et al. (2007) reported that supertaster have higher abilities to discriminate custard but found inconsistent associations between taster status and the intensity of 10 texture characteristics in vanilla custard, with no clear correlation between attributes that were similarly influenced by taster status.

1.5.2. Odor Sensitivity

Phenotypical variations in odor perception include anosmia to certain aromas such as trimethyl amine (marker of fish spoilage), androstenone (boar taint), diacetyl (butter-like), and cineole (a terpene in herbs). The olfactory receptor proteins are responsible for detecting various odor substances. Buck and Axel. (1991) confirmed that there were a hundred of various genes encoding olfactory receptor molecules. They also suggested that the brain realizes diverse odors through a recognition system where various aroma substances bind to a various set of receptors. Recently, literature have found associations between genotypic differences in certain aroma receptors and differences in pleasantness and intensity perceived for presented aromas (Buck &Axel., 1991).

Keller and his colleagues concluded that variants of OR7D4 were the main responsible for variations in perceived pleasantness and intensity ratings of individuals to androstenone (Keller et al., 2007). In another recent research, it was recognized 27 aroma receptors with functionally various alleles and used *in vitro* researches to know the consequences of various alleles and their impact on the extent of odor receptor response to dual odorants (Mainland et al., 2014). They also revealed that there is a difference in OR10G4 to clarify over 15% of the difference the perceived intensity of guaiacol (Mainland et al., 2014). Another odor considered to have a massive inter-individual variation in both aroma descriptor and perceived intensity is β-ionone, which is an aroma commonly exists in foods. Jaeger and his colleagues found that more than 96% of the phenotypic difference was clarified by genetic variations in OR5A1 (Jaeger et al., 2013).

1.5.3. Texture Sensitivity

Consumers usually characterize food in terms of flavor and taste, whereas texture is often not indicated. However, texture of food is considered a fundamental determinant for the appreciation of food. Fresh potato chips will be perceived and appreciated as crispy, whereas a few days later, the chips will not be consumed as they will be stale (Christensen & Vickers., 1981). Texture is not just essential for the appreciation, but also for the recognition of food. (Pereira & van der Bilt., 2016).

There are various factors including both subject and product related, that can affect texture perception **(Figure 1.2)** (Engelen & Van Der Bilt, 2008). Texture of food can be characterized by expressions or properties such as thick, thin, crunchy, smooth, astringent or soft, and each property can refer to a particular textural property. Texture is highly related to the structure of the food. Sensory texture evaluation is commonly performed in combination with instrumental measurements, used to determine the rheological characteristics of food (Chen., 2009). Rheology clarify the relation between time, force, and deformation. Measurement instruments range from simple hand-held devices to Instron machines and texture analyzers, which provide time-series data of product deformation (Chen &Opara., 2013).

Furthermore, texture is perceived outside the mouth (extra oral). Since visual cues such as shine, grains, heterogeneity (lumps), and color gives information on the texture of the food. Extra information can be acquired by handling the food, for example spooning, cutting, and stirring, (Pereira & van der Bilt., 2016).

Intraoral factors can influence the food itself and how it is perceived, for example thermal perception, dentition, swallowing, composition and amount of saliva, sensitivity of the mouth to size and touch, proprioception, and tongue movement. Oral contact with food can happen through the palate, tongue, lips, teeth, and cheeks, all of which gives textural information. During mastication, the texture of solid food is perceived through oral receptors, which relay information about pressure, vibration, slip and movement in the mouth. In addition, muscle spindles and Golgi tendon organs transduce information on the forces and length of masticatory muscles and thus on bite force and position of the lower jaw. In this way, information is obtained on food characteristics, such as hardness, toughness and crunchiness (Pereira & van der Bilt., 2016).

Finally, the central nervous system (CNS) is an essential factor in texture perception. Emotional state and memory of the person eating the food, time of day, and social background. During exposure to various foods, the appreciation and perception of food will be changed due to experience. In various cultures, various textures are favorable, such as stickiness and pliability in Japan (Pereira & van der Bilt., 2016).

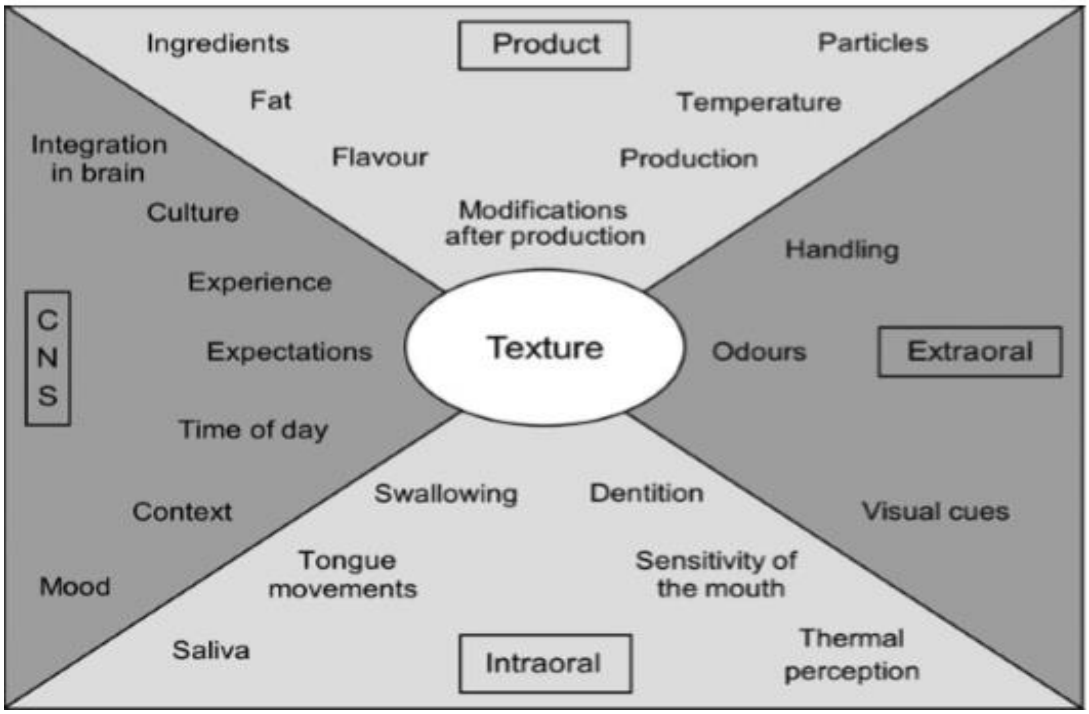


Figure 1.2. Diagram of factors that may influence food texture.

2. Objective of the Research

The main objective of this research was to determine sensory freshness of an Italian traditional bakery product, *focaccia from Apulia region*, using a rapid sensory method (e.g. CATA). Two different formulations of *focaccia* samples were chosen as bakery products. *Focaccia* samples were provided by Oropan S.p.A (Altamura, Bari, Italy). As a secondary objective, it was also investigated how consumer sensory sensitivity would affect freshness perception of focaccia samples. The experimental plan of this research was shown in the following flow chart (Figure 2.1)

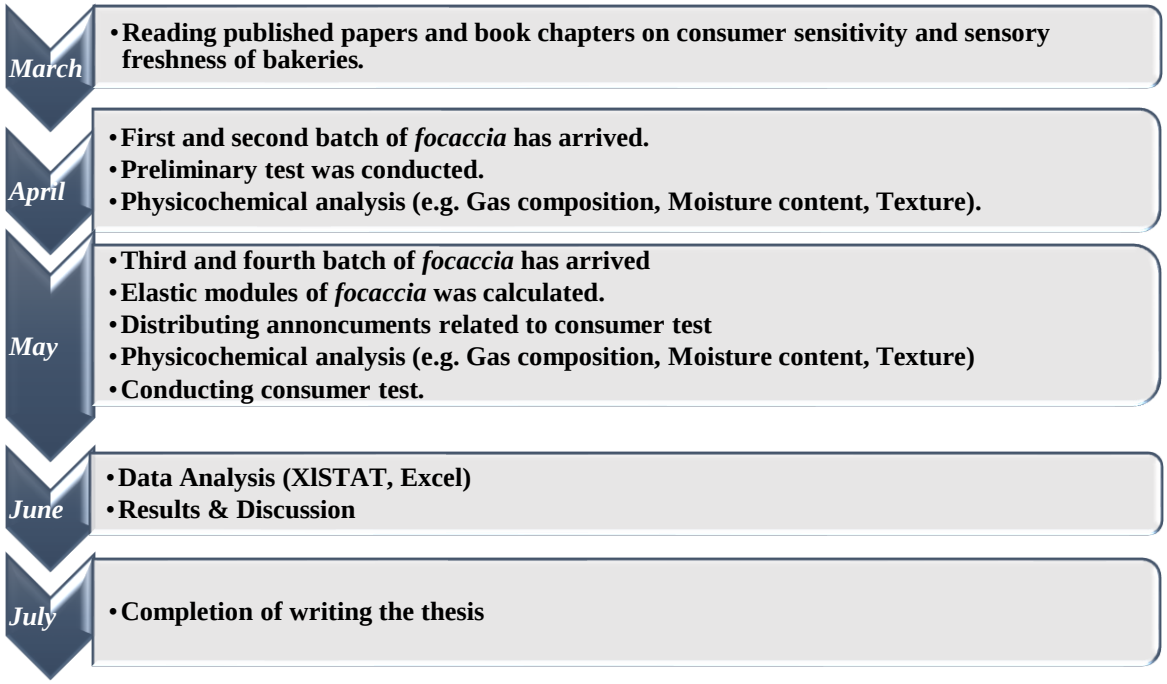


Figure 2.1. Flow chart of the experimental plan

On the 9th April, the first batch of *focaccia* has arrived. The batch contained seven samples of *focaccia* which differ only in their toppings including; olives &oregano (FO1), olives &extra virgin olives oil (FO2), defrozen olives (FO3), defrozen onion (FN1), frozen onion (FN2), tomato &olives with less extra virgin olive oil (FT1), tomato &olive without salt (FT2), and non-diluted tomato sauce (F4). So, it was decided to perform preliminary teste for *focaccia* samples to observe the difference between samples with similar toppings including; FO1, FO2, and FO3 samples, FN1, and FN2 samples, FT1 and FT2 samples.

The preliminary results reveal that there are no differences between the samples mentioned above. Thus, we have asked the Oropan factory to produce four different toppings of *focaccia* including; tomato &olive with less oil and without salt (F1), frozen onion (F2), dehydrated onion (F3), and tomato sauce not diluted (F4). On 17th April, the second batch of *focaccia* has arrived. The batch contained four samples of *focaccia* as it was requested. Physiochemical analyses are performed, every time a new batch arrives.

On 3rd May, the third batch of *focaccia* has arrived. The batch contained three samples of *focaccia* including; F1, F2, and F3. On the 2nd week of May, the announcements related to consumer test has been distributed in the department of agriculture and areas near the department. Announcements were also published on the department's offical website. On 24th May, the fourth batch, which contained three different samples of foccacia; F1, F2, and F3, has arrived. Two days before the testing day, the sessions was built on the PC and it was decided which *focaccia* samples (F1 &F2) will be used. On the consumer test day, gas composition was measured for every sample of foccacia before it is tested. Consumer test was performed during 27th to 31st May. Physiochemical analyses were performed, every time a new batch arrives.

In June, all the data were statistically analyzed according to the type of variables by using Microsoft Excel. The CATA data were organized in a contingency table with binary responseand were subjected to ANOVA using the XLSTAT software.

2.1. Hypotheses

There were two main purposes of the current research: First, we wanted to investigate if the storage time could affect the description of the product. Second, we examined the association between consumers' sensitivity and food preferences. Thus, it was hypothesized that the longer storage time, the more the decrease in positive attributes and the more the increase in negative attributes of the product happen. Moreover, it was assumed that consumers' sensitivity could affect their food preferences and the freshness perception of *focaccia* during storage time.

3. Materials &Methods

3.1. Management &Organization of the Research

The data Collection was done between 4th April to 31st May 2019. All participants were briefed about the study design and objectives, and they were informed about the type of tests that would be included in the consumer test, with affirmation on their optional participation. The study protocol was approved by the Ethics Committee of University of Naples. The participants gave their written informed consent at the beginning of the test according to the principles of the Declaration of Helsinki.

3.2. General Research Methods

3.2.1. Overview of data collection

At the time of selection, participants were informed general information about the research objectives. They were required to fill in an online questionnaire (Appendix B) at home in the days prior the data collection and requested to attend one session at the sensory laboratories of Naples. Appendix A illustrates the process of data collection.

On data collection day, consumers, were given general information about the session. The session was composed of five tests which involves; check all that apply (CATA) method for two types of *focaccia* samples, checking odor sensitivity by using odor pens, measurement of PROP responsiveness, and measuring consumer response to jelly hardness. There was a fixed breaks of 5 minutes between each test. Consumer were allowed and encouraged to ask question about, and to comment on the method in order to give them a feeling of being part of a serious research project, and therefore maximizing their motivation and attention and averting tedium and weariness. Within these breaks, consumers are given guidances on scaling techniques (9-point hedonic scale, LAM scale, and gLAM scale) (Appendix E).

Consumers were seated in individual cabins and introduced to the use of the PC for data collection. All cabins were well-illuminated with white light designed to avoid masking visual differences

between the tested products. The cabins were also separated from each other to avoid distraction and any communication among consumers. A maximum of 8 consumers were tested at one time. The session took approximately 45minutes.

The first session usually begun at 9:00 o'clock, and it is initiated with CATA test for one type of *focaccia* samples (e.g. *focaccia* with frozen onion and oregano), followed by odor sensitivity test. Then, another CATA session were applied for another type of *focaccia* sample (e.g. *focaccia* with tomato &olive). Then, they were instructed about PROP test. In the final part of the session, they were given guidelines on how to evaluate their response to candies hardness (Appendix E). At the end of the session, consumers are compensated for their time with a gift (*focaccia* sample).

3.3. Materials

3.3.1. Sample & Storage conditions

In this research, it is used two different toppings of *focaccia*; tomato & olive with less oil and without salt (F1), and frozen onion with oregano (F2) at four different storage times. The *focaccia* samples were kept at varying intervals of storage times prior to testing. The storage times were 7 days, 30 days, 45 days and 60 days. The samples were stored at room temperature then cooked at 180°C for 10 minutes and presented to consumers. Once the *focaccia* is heated, it is cut into quarters; each quarter of *focaccia* weigh approximately 63g **(Figure 3.1)**. Each storage time had a random 3-diget code. The code is written on the plate and the *focaccia* sample is placed underneath for clear identification. The consumers continued with the test until the two formulations of *focaccia* are analyzed, sensitivity tests are performed, and questionnaires are completed. Consumers are instructed to take a break between eating *focaccia* samples and to rinse their mouths with water.

Figure 3.1 Frozen Onion with Oregano sample on the left side &Tomato with less oil &without salt sample on the right side.

3.3.2. Nutritional Value of *Focaccia* samples

According to Oropan S.p.A, a 100g of *focaccia* provides 292 kcal. Most of the calories (64%) come from carbohydrates and (26%) of the calories come from fat, while protein has little contribution to *focaccia's* calories with a percentage of 10%. **Table 2.1** illustrate the nutrition facts of *focaccia* per 100 g.

Table 2.1. Nutrition Facts Label Per 100 g*

	Per 100 g
Energy	292 kcal
Fat	8.5 g
Saturated Fat	1.1 g
Carbohydrates	46.5 g
Sugar	2.8 g
Protein	7.5 g
Salt	2g

3.3.3. Preliminary Sensory Test for *Focaccia* samples

The first batch of *focaccia* contained seven different samples that only differ in terms of their formulated topping; *focaccia* with olives & oregano (FO1), *focaccia* with olives &extra virgin olives oil (FO2), *focaccia* with defrozen olives (FO3), *focaccia* with defrozen onion (FN1), *Focaccia* with frozen onion (FN2), *focaccia* with tomato &olives with less extra virgin olive oil (FT1), *focaccia* with tomato &olive without salt (FT2). Each sample was heated at 180ºC for 10 minutes previous each test, by the sensory analysts in the kitchen of sensory laboratories of Naples and immediately served to the panelists. A preliminary test was done to examine the presence of differences between the FO1, FO2, FO3 samples, FN1 and FN2 samples, FT1 and FT2 samples that could be perceived by all panelists. The preliminary test was conducted on 40 trained subjects (31 males, 9 females) recruited from food science and technology department.

Data collection was accomplished in a one day (9:30 a.m. to 5:00 p.m.) in 4 individual cabins at the sensory laboratory of the Food Science and Technology Division (Department of Agricultural Science, University of Naples – Federico II). All booths were well illuminated with white light designed to avoid masking visual differences between the tested products and detached from each other to avoid distraction and any communication among panelists. After an explication of the test the panelists were directed to stratify the process and standards of discrimination methods before performing each test.

The sensory evaluation of *focaccia* was performed in several parts. The first part had the objective of verifying the differences between FN1, and FN2 samples. For this purpose, the Triangle Test was applied under controlled conditions (Meilgaard et al. 2006). Once inside the cabins, the panelists received a standard *focaccia* sample (15g) and two unknown (15 g) samples of *focaccia*; one was the same as the standard *focaccia* sample and the other was unidentical. All samples were served on white rectangular plastic plates.

The main target of the second part of preliminary test was to verify which samples are salty and which samples are oily? Panelists received a white plastic plate containing two coded samples of *focaccia*.

The third part of preliminary test was done to rate the hardness of olives. A nine-point hedonic scale (1=extremely low intensity,9=extremely high intensity) is used to rate the hardness of olives.

The preliminary test underlined that there were no differences in terms of hardness between FO1, FO2, FO3 samples, no differences in terms of flavor between FN1, FN2 samples, and FT1, FT2 samples.

3.4. Methods

3.4.1. Consumer Sensitivity &Consumer Test

3.4.1.1. Consumers

The participants were selected from Naples region of Italy. To be included, the participants had to be aged between 20 to 70 years, can visit University of Naples for the scheduled visits, should be familiar with consuming *focaccia*. The exclusion criteria included being allergic to gluten " i.e. celiac disease", having chewing and/or swallowing problems, having taste and/ or smell disorders, taking any medicine as a treatment of cancer or thyroid, neurologic, or psychiatric ailments, suffering from impairments which may prevent mental comprehension of the research, or informed consent from being given, or being critically ill "i.e. cold, fever, gum inflammation". Participants are recruited by means of announcements published on the Department of Agriculture Sciences social network websites (Facebook), and by distributing flyers in Portici region.

3.4.1.2. Online Questionnaire

In the current research, online questionnaire was used in order to gather information related socio-demographic, physical health, anthropometric, liking and frequency of consumption **(Appendix B)**.

The questionnaire was developed after reviewing many studies regarding food choices and preferences, and food liking. The first outline of the questionnaire is written in Italian language and is drafted by two postgraduate students. Face validity is done by sending the primary draft of the questionnaire to one evaluator; who is holding a PhD degree in food science and technology. Her feedback was considered in language corrections, rewording and delete some questions.

The questionnaire includes multiple choice questions (select one) and open-ended questions to collect further details. There were also three sections regarding liking, food preferences, and food consumption, which aimed to eliminate consumers who don't like focaccia and don't eat it often, so only desired consumers who like *focaccia* were selected for sensory evaluation. The consumers were asked to tick a box in the presented table in order to state how much they like the focaccia. Boxes ranges from extremely disliked (1) to extremely liked (10).

3.4.1.3. Consumer Sensitivity

3.4.1.3.1. Taste Function Indices

We have performed a PROP test in order to divide consumer based on their taste sensitivities. Details on PROP test is described below.

PROP Taster Status

The PROP solution is prepared before the test's day as it needs to be mixed for 24 hours. A 3.2 mM PROP solution is prepared by dissolving 0.5447 g/L of 6-n-propyl-2-thiouracil into 1 Liter of deionized water. Consumers are presented with two identical cups of PROP solution (10 ml). Each cup is coded with different 3-diget code. Solutions were presented at room temperature. Consumers are instructed to hold each sample (10 ml) in their mouth for 10 seconds, then expectorate, wait 20 seconds, then estimate the intensity of bitterness using gLMS (Bartoshuk et al., 2004). A break of 90 seconds was necessary to control the carry-over effect after the first sample estimation. Within

the break, consumers are advised to rinse their mouths with distilled water for approximately 30 seconds. The average bitterness score is used for each consumer

3.4.1.3.2. Sensory Stimuli

We have used sensory stimuli (odor pens in our research) in order to divide consumer based on their odor sensitivities. Details on odor test is described below.

Odors

Identification, irritation, and intensity are evaluated for each odor. Four different odor pens are presented to consumers: onion, garlic, peach and honey. The odor pens are kept in the fridge, from there they are given directly to consumer. Each pen is randomly coded with a different 3-digit code. First, the odorant is presented, and the respondent is asked to identify the name of the odor among four possibilities. Then, the respondent is required to estimate the odor's liking, intensity, its degree of irritation by using 9-point hedonic scale (Peryam& Pilgrim., 1957). The odorants are presented in a randomized order and consumers are instructed to take a break of one minute between each evaluation. The average liking, intensity, and irritation scores are used for each consumer.

3.4.1.3.3. Texture Sensitivity

We have used a hardness sensitivity index as a measure to evaluate consumers sensitivities to texture. So, we prepared four types of candies made of different concentrations of agar. Details on how they prepared and how the test is performed is described below.

Candies Preparation

The candies are prepared one day before the test. The candies are made by mixing agar with grapefruit juice. Then, the solution is heated to 97ºC, stirred continously, and left to cool at room temperature until the cosistency of the liquid become hard like a jelly. At last, the jelly must be kept in the refrigerator for 12 hour. Four different concentrations of agar "3%, 5%, 7%, 9%" are used; 3% being least sweet and 9% being the most sweet. Each candy is randomly coded with a different 3-diget code. The candies are presented on a plastic plate divided into four sections and given to consumer. Consumers are given water to rinse in-between candies samples.

First, the candies are presented, and the respondent is asked to evaluate how much he/she likes each candy by using LAM scale (Schutz& Cardello., 2001). Then, the respondent is required to estimate the candy's hardness by using gLAM scale (Bartoshuk et al., 2004). Consumers are instructed to take a break of one minute between each evaluation. During this break, they are asked to rinse their mouths with water. The average liking and hardness score are used for each consumer.

3.4.2.1. Consumer Test: CATA

CATA ('check all that apply') is a question with a list of phrases which are selected by the consumer to be a chosen attribute for the product. First, consumers were asked if they consume this like this type of *focaccia* or not. Next consumers were asked to check all attributes that applied to the given sample (Ares et al., 2013).

3.4.2.1.1. List of Attributes

A former report, which was conducted in February 2019, was used in order to generate a list of attributes. The former research found that that assessors agreed on best descriptors "22 attributes for each type of *focaccia* sample". Two days before testing day, a list of attributes for each type of *focaccia* was defined by a focus group with three non-trained assessors. Hence, the attributes for each type of *focaccia* were completely different (Appendix G).

3.6. Statistical Analysis

3.6.1. Socio-demographic Data

Missing data were minimal. Descriptive statistics were also used to analyze socio-demographic information by using Microsoft Excel. Categorical data were described as frequencies and percentages. Independent data was described as a mean ± standard deviation.

3.6.2. Check-all-that-Apply (CATA)

The CATA data were organized in a contingency table with binary response (0 = attribute not mentioned, 1 = mentioned attribute) and were subjected to Correspondence Analysis using the XLSTAT software. This analysis provides a sensorial map of the samples, which allows to determine the similarities and differences between the products under examination, as well as the sensorial attributes that characterize them. With the Principal Coordinate Analysis, a graphical representation was obtained which made it possible to evaluate the correlation between sensory attributes and acceptance of the samples under examination. Finally, through penalty analysis it was possible to determine the effect of the Presence / Absence of each attribute on the variation of the average liking judgment.

3.6.3. Survival Analysis

The experimentation was performed using a complete factorial design, where the total number of analyzed samples (N) is equal to the product of the analysis time (T) for the number of consumers (C) (TxC). The data related to the satisfaction, expressed through a positive or negative response, were treated through the procedure of "censorship data" (Hough et al., 2003). The procedure considers that the consumer analyzes the samples at discrete time intervals, therefore the answers can be classified into three different categories: (i) the category of data "censored on the right", which represents the consumers who considered that the product is acceptable at each time of evaluation; (ii) the category of "censored at intervals" data, which represents all consumers who have expressed a negative evaluation at a defined time; (iii) the category of data "censored on the

left", which represents the consumers who expressed a negative assessment at the first time of evaluation.

Thus, the elaborated data were further analyzed in order to estimate the rejection function and the respective complementary acceptability function. This function indicates that the probability of the risk that the product is not accepted by the consumer can be verified. To this end, the analysis of the data provided for a first phase of identification of the distribution function that best explains consumer behavior and a second phase of estimating the parameters of the function. Note the function it is therefore possible to estimate the shelf life at different levels of risk related to the occurrence of the negative event, or the non-acceptability of the product.

The Weibull ++ software (Weibull ++ 7, ReliaSoft, USA) was used for performing survival analysis. **Table 3.1** shows the models used to correlate the data.

Table 3.1 List of statistical models used for the description of the data.

Statistical Model	
Loglogistic	Weibull 3
Lognormal	Logistic
Exponential 2	Gamma
Weibull 2	Normal
G-Gamma	Exponential 1
Gumbel	

Parameter estimation was done by maximizing the *Likelihood* function. The regression method used was the ranking *regression methods* and the method used to calculate the confidence intervals was the *likelihood ratio* (LRB). The method for ranking the function was the *Median Ranks* (MED). The choice of the best model was made based on the following parameters:

- AVGOF (Average goodness of fit): corresponds to the average values of the goodness of the fitting; low values indicate a good fit of the data.
- AVPLOT: corresponds to the normalized measurement of the quality of the fitting;
- LKV (log likelihood function): corresponds to the logarithm of the likelihood function.

These values are further processed to estimate the following parameters:

- RAVGOF: the ranking with respect to the AVGOF parameter;

- RAVPOLT: the ranking with respect to the AVPLOT parameter;
- RLKV: the ranking with respect to the LKV parameter;
- DESV: final ranking based on which the model is decided.

This number derives from the product of the three previous parameters for a weight factor indicated in the analysis method. The distribution with the lowest value of DESV is the distribution with the highest ranking.

3.6.4. Consumer Sensitivity

PROP Status

For the PROP status, we analysed the distributions of data (by means of descriptive statistical tools) by using Microsoft Excel. PROP ratings were first categorized using the characteristic values of the percentile distribution (first and third quartiles); then, three dichotomic variables were considered: Non-Taster (NT), Medium-Taster (MT) and Super-Taster (ST).

Odor Sensitivity

We used only onion odor as a criteria to divide the consumers into groups according to their sensitivies, since this odor was not recognized correctly by consumers as they did with other odors. At first, according to consumers' ability to recognized odor, they were clustered into two groups: high sensitive (HS) and low sensitive (LS). Then, HS group were also clustered into to two groups: high sensitive (HS) and Medium sensitive (MS), this step was done according to the mean intensity score of consumers' odor perception. At the end, we had three groups of consumers based on their odor sensitivity: LS, MS, and HS.

Texture Sensitivity

The model was chosen taking into account the ability of consumers to discriminate between the samples. The four hardness scores of each subject were interpolated with a linear equation. Therefore, for each subject, the angular coefficient and the value of R2 were obtained. After examining the values of the angular coefficients and the corresponding R2 values of each subject,

the criteria for dividing people into groups were chosen. Then, three dichotomic variables were considered: LS, MS, and HS.

In order to verify if there is a relationship between the liking scores of the samples and consumer sensitivity groups or socio-demographic data (age, gender). We conducted one-way ANOVA and Duncan test using XLSTAT software. In particular, we considered demographic variables (gender and age), and sensitivity groups as independent variables and the liking scores as dependent variable. And a nominal level of significance is set to be 0.05.

4. Results &Disscussion

4.1. Molds Monitoring

The molds was checked for each batch and for each type of *focaccia*. Mold monitoring is carried out twice a week.

For batch I, molds was monitored for 60 days. After 42 day of storage, molds were found on only one sample out of 40 sample of *focaccia* with tomato &olives (F1). But no molds were found on samples of *focaccia* with frozen onion &oregano No other mold was found until the 60th day of storage.

Mold monitoring for batch II was done for 60 days. No molds were found in any of the types of samples during the entire storage period.

For batch III, checking molds was done for 55 days. On 39th day of storage, molds were present in only one sample F1(3.7%) out of 27 samples. On the other hand, no molds were found on samples F2.

Mold monitoring for batch IV was done for 30 days. On the 30th day of storage, molds were found on only one sample F1 (1.5%) out of 66 samples. When samples F2 were visually inspected on the 30th day of storage, no molds were found. However, by measuring the gas composition of the samples, it was found that the oxygen inside some packages was zero. Therefore, these samples have been considered as moldy samples. At the end, it was considered that 4 samples (6%) out of 66 to have molds. Table 4.1 summarizes all the data related to the presence of molds on two types of *focaccia* samples for all the batches.

Table 4.1 Data related to the presence of molds on two types of *focaccia* samples for all the batches

Batch Number	**Product**	**Production Date**	**Total number of *focaccia* once they arrived**	**Number of *focaccia* with molds**	**The day when the molds were found**
I	***Focaccia* with tomato & olive (F1)**	1st April 2019	40	1 (2.5%)	42
	***Focaccia* with frozen onion &oregano (F2)**	1st April 2019	52	0	-
II	***Focaccia* with tomato & olive (F1)**	15th April 2019	62	0	-
	***Focaccia* with frozen onion &oregano (F2)**	15th April 2019	62	0	-
III	***Focaccia* with tomato & olive (F1)**	6thMay 2019	27	1 (3.7%)	39
	***Focaccia* with frozen onion &oregano (F2)**	29thApril 2019	30	0	-
IV	***Focaccia* with tomato & olive (F1)**	22ndMay 2019	66	1 (1.5%)	30
	***Focaccia* with frozen onion &oregano (F2)**	22ndMay 2019	66	4 (6%)	30

4.2. Commercial Shelf Life of *focaccia*: Survival Analysis

Based on the positive or negative answers to the following question **"Would you normally consume/ buy th product?".** Relating to samples stored at different times, consumers were grouped into 4 categories.

1. Type 1: represents the typical consumer in a shelf-life study; in other words, they reflect the consumers who accepts the samples up to a certain storage time and then rejects them. The following data is identified as "interval censorship" data. The interval is established based on the last positive answer and the first negative answer.
2. Type 2: represents consumers who accept the samples at all times of storage. In this case the data are considered data "censored on the right". These data indicate that the risk that the product may not be liked falls at a time greater than the last time of the analysis.
3. Type 3: represents consumer who appear to be rather inconsistent, in some cases interrupting positive and negative responses. This censorship data could be interpreted in different ways. One possibility could be by eliminating consumers as they are not coherent, or a wider range can be considered, excluding only uncertain answers. This option allows not to change the number of consumers but increases the uncertainty in the estimate of the rejection function. It was decided to proceed considering the consumers and using the data as "interval censorship" data.
4. Type 4: represents consumers who reject the fresh sample, therefore the consume may have been recruited by mistake, since the consumer did not like the product, or preferred the stored products rather than the fresh product, or might not understand the question. In this case it would not be reasonable to consider the results of these consumes, they have been eliminated from the results.

Tables 4.2 and **4.3** summarizes the types of answers given by the different consumers. As shown in **Table 4.4,** all consumers who did not like any sample were probably eliminated, probably because they were wrongly recruited, or they did not understand the task. Therefore, the Survival analysis was conducted on 85 consumers for *focaccia* with tomato &olive (F1) and on 81 consumers for *focaccia* with frozen onion &oregano (F2).

Table 4.2 Example of consumer behavior (1: yes; 0: no) and classification of consumers for sample F1.

Number of the Consumer	**7 d**	**30 d**	**45 d**	**60 d**	**Censorship**	**Category of consumers**
1	1	1	1	0	Interval 45-60	1
2	1	1	1	1	>60	2
3	1	0	0	0	Interval 7-45	3
4	0	0	0	1	Excluded	4

d: days.

Table 4.3 Example of consumer behavior (1: yes; 0: no) and classification of consumers for sample F2.

Number of the Consumer	**7 d**	**30 d**	**45 d**	**60 d**	**Censorship**	**Category of consumers**
1	1	0	1	0	interval45-60	1
2	0	1	1	1	> 60	2
3	1	0	0	1	interval7-45	3
4	0	0	1	1	Excluded	4

d: days.

Table 4.4 Number of consumers for each category for the different types of samples.

Product	**Category 1**	**Category 2**	**Category 3**	**Category 4**
***Focaccia* with tomato & olive (F1)**	26	35	24	14
***Focaccia* with frozen onion &oregano (F2)**	24	30	27	18

Figures 4.1 and **4.2** show the results of the analyzed data related to the responses to the following question: "in a normal consumption condition, would you consume the product?" The storage time of the product is shown on the abscissa axis. Each line represents a consumer behavior. The green lines indicate that the consumer has considered the product acceptable at all times of analysis. Therefore, they represent consumers belonging category 2. The red lines represent the behavior of consumers who have rejected the product at one time of the analysis. The **X** shown on the lines indicate the last time the product was considered acceptable (on the left) and the time it was rejected.

Figure 4.1 Application of censorship data to the responses given by consumers to sample F1

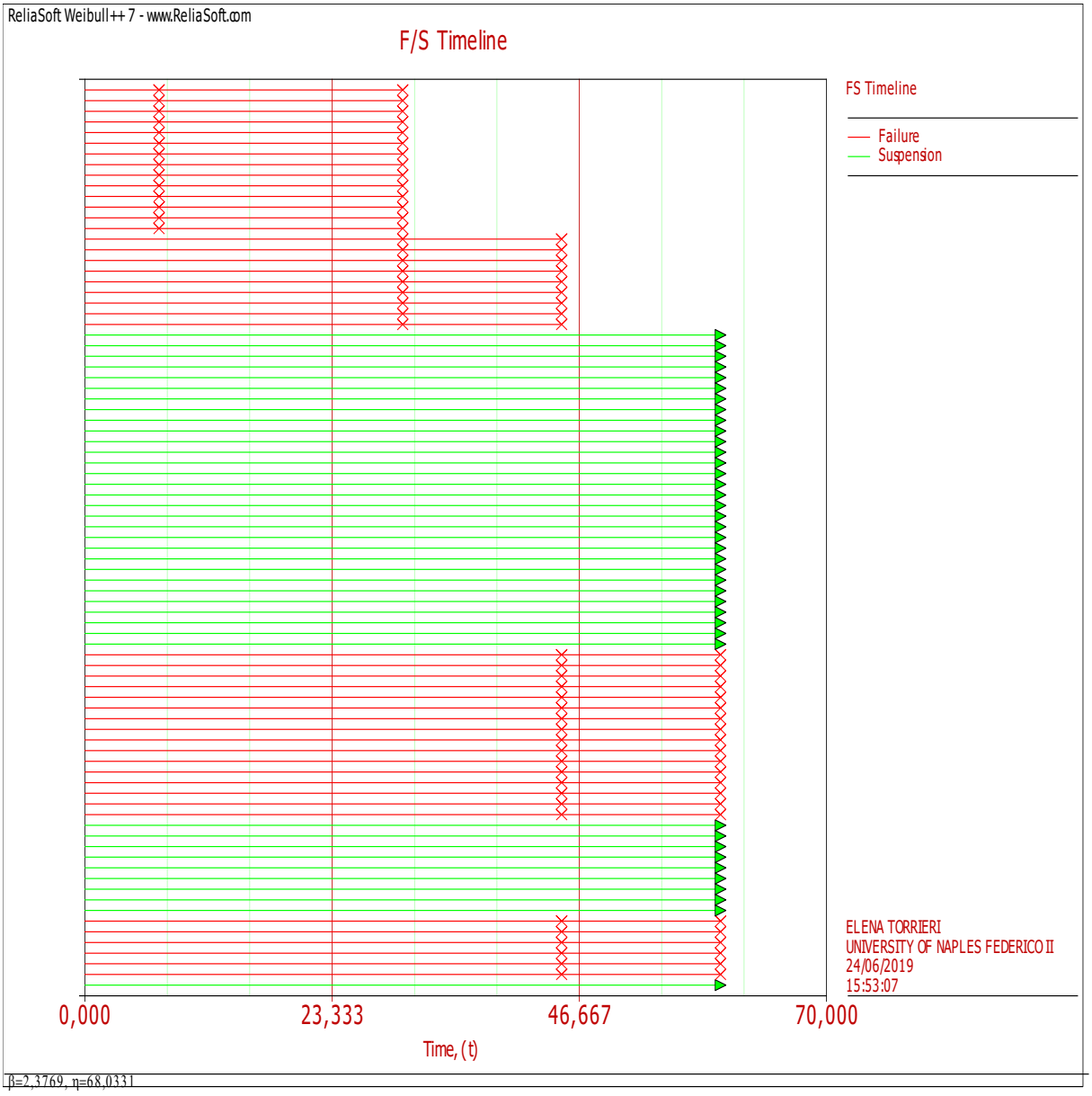
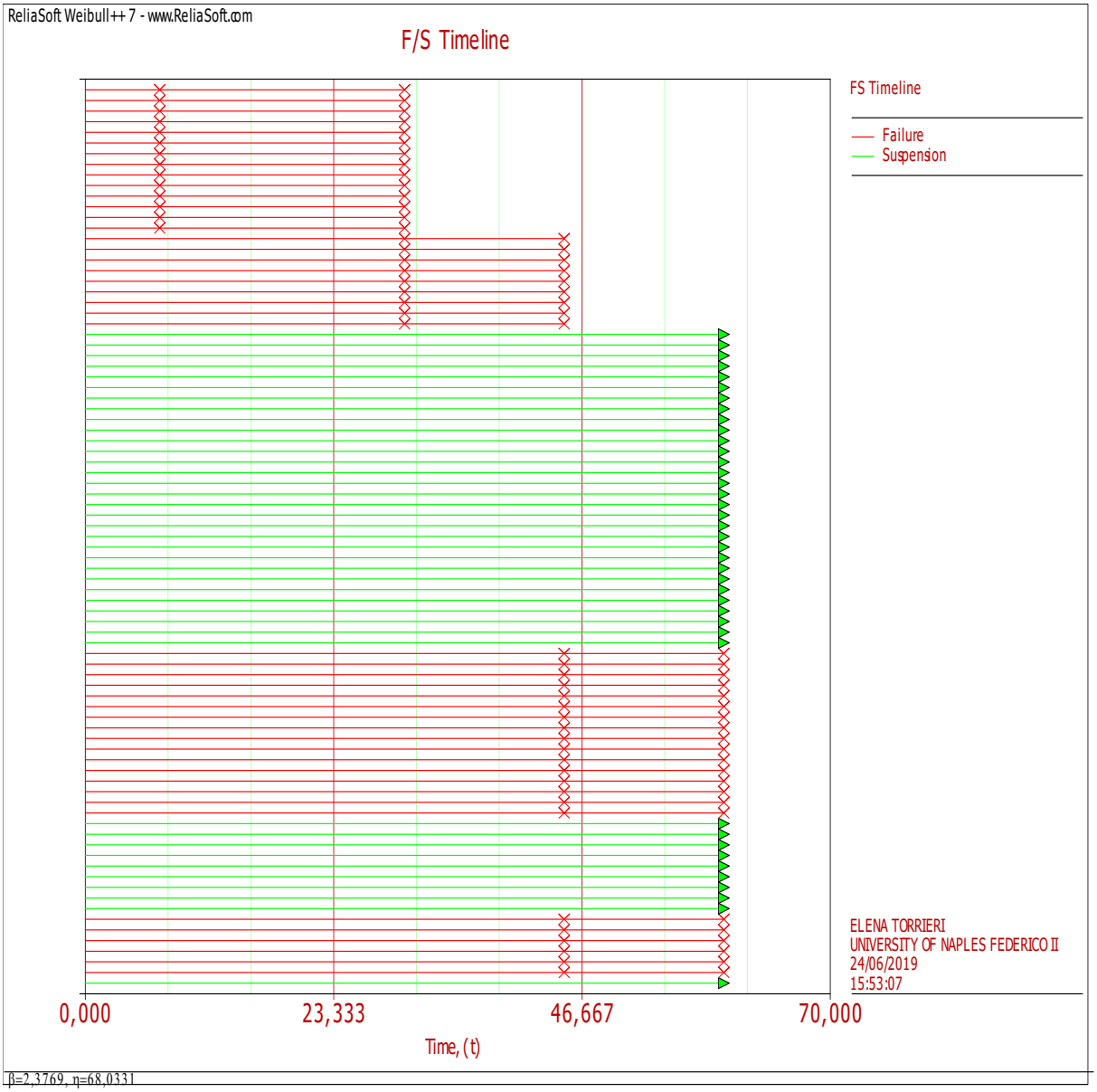


Figure 4.2 Application of censorship data to the responses given by consumers to sample F2



From the analysis, we can observe that for samples F1, approximately (47%) of consumers considered that the product is acceptable up to 60 days **(Figure 4.3)**. However, for samples F2, the

percentage of consumers who consider the product acceptable up to 60 days is slightly higher (51%) **(Figure 4.4)**.

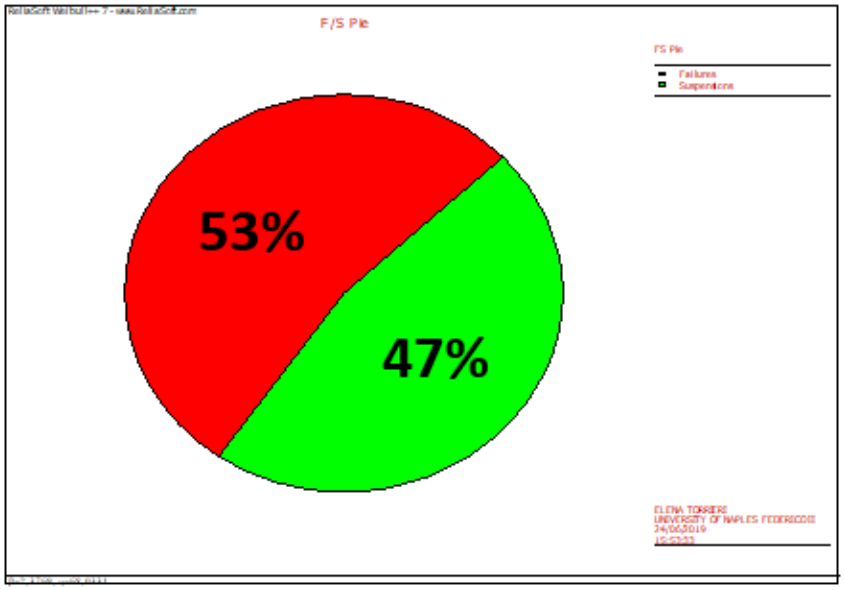


Figure 4.3 Acceptance and unacceptance data for sample F1

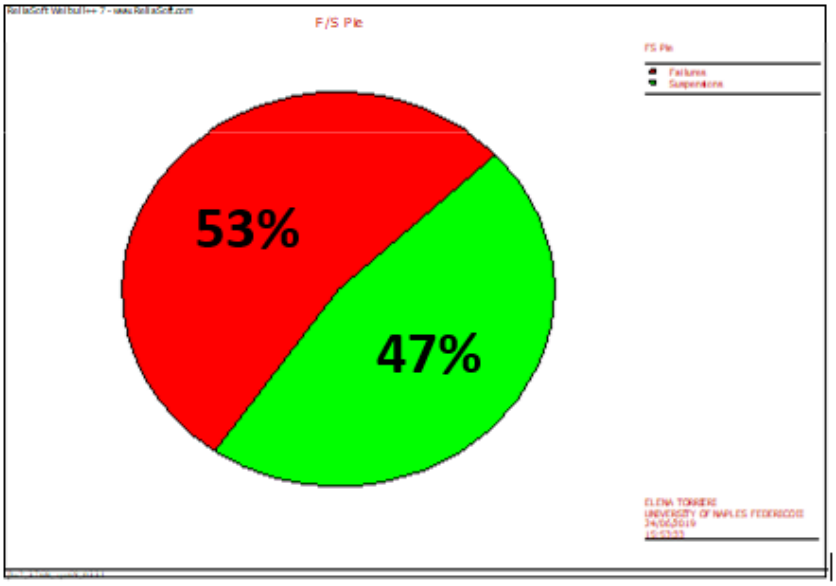


Figure 4.4 Acceptance and unacceptance data for sample F2

Figures 4.5 and **4.6** show the rejection functions related to the acceptability of sample F1 and F2, respectively. The data is well described by a two parameter Weibull distribution function. Hence,

The points represent the experimental data, whereas the line represent the description of the function using a theoretical model.

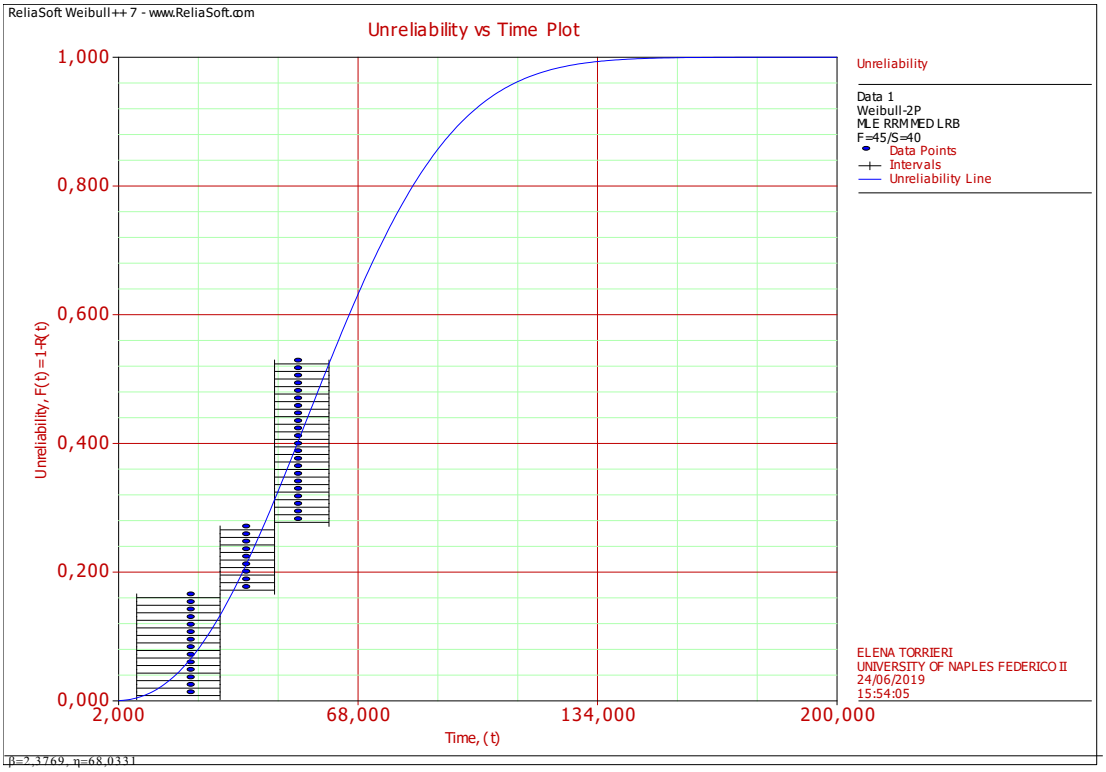


Figure 4.5 Rejection function related to consumer acceptability of sample F1 as a function of time.

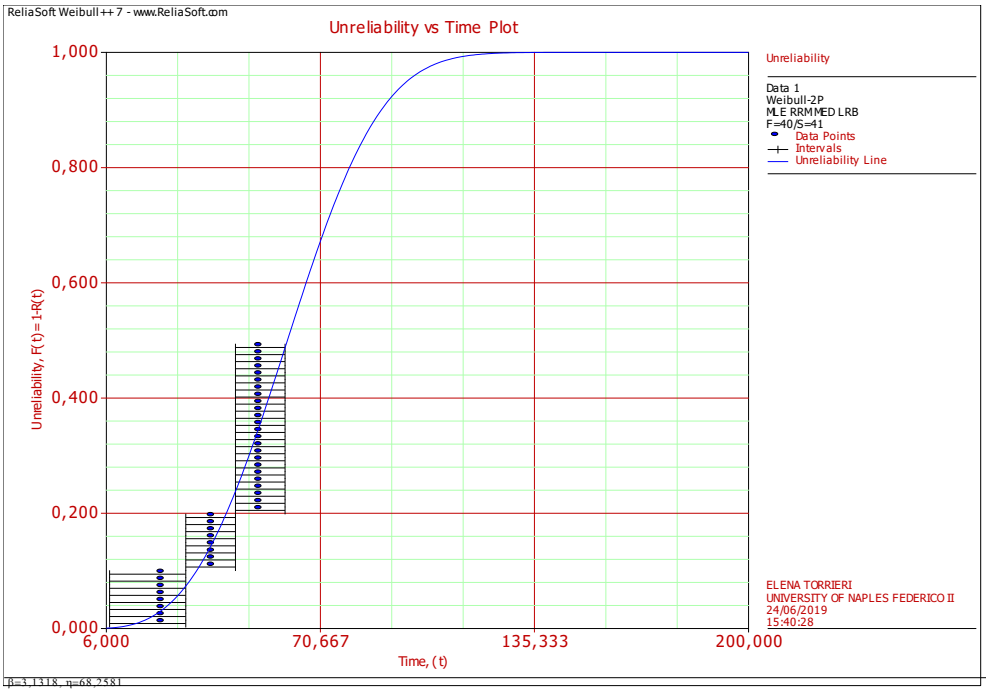


Figure 4.6 Rejection function related to consumer acceptability of sample F2 as a function of time.

Table 4.5 shows the parameters of the estimated models for samples F1 &F2. Starting from these data, it is possible to proceed, through the processing of censored data, to determine the shelf life of the products.

Table 4.5 Parameters of the Weibull function and value of the likelihood function for samples F1 &F2.

Product	**η (h^{-1})**	**β**
***Focaccia* with tomato & olive (F1)**	68.03	2.37
***Focaccia* with frozen onion &oregano (F2)**	68.25	3.13

Based on the rejection function, it is possible to estimate the shelf life based on a specific probability by which the product is not liked by the consumer. **Table 4.6** shows the shelf life values according to the product acceptability percentage

Table 4.6 Shelf life estimated at different risk levels

Product	**Shelf life (d) depending on the percentage (%) of product acceptability**		
	80%	50%	30%
***Focaccia* with tomato & olive (F1)**	42±5	61±5	72±8
***Focaccia* with frozen onion &oregano (F2)**	36±5	58±6	74±9

d: Days

In correspondence to 80% probability that consumers consider the product acceptable, or at low risk that the product may not be appreciated, the shelf life of the products takes values between 36 days for sample F1 and 42 days for sample F2 and. By increasing the risk to 50%, the shelf life varies between 58 days for sample F1 and 61 days for sample F2.

4.3. Consumer's Characteristics

4.3.1. Socio-demographic Characteristics

Consumers' socio-demographic characteristics are presented in **Table 4.7**. The research consisted of (32%) males and (68%) females. Nearly the majority of the consumers (84%) are stated to be single, while (15%) are married and only (10%) stated to be widow. The mean age of the sample was (23 ± 11.19). The statistical analysis also reveal that (48%) of consumer belong to age group below 25 years. The procedure of recruiting consumers is described in **Figure 4.7**.

Table 4.7. Consumers' Socio-demographic characteristics presented in frequencies (F) and percentages (%)

Variables	**Frequency (F)**	**Percentage (%)**
Gender		
Male	32	32.3
Female	67	67.7
Age groups		
< 25 years	47	47.5
>25 years	52	52.5
Marital Status		
Single	83	83.8
Married	15	15.2
Widow	1	10.1

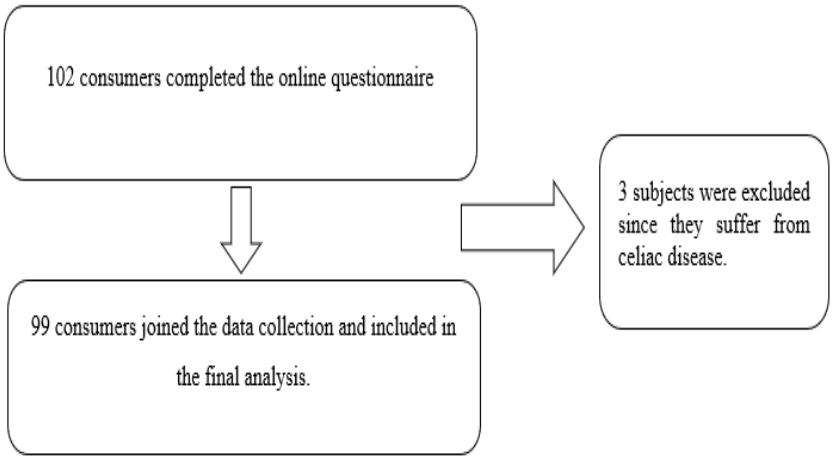


Figure 4.7 Consumers recruitment flowchart.

4.3.1.1. Relationship Between Socio-Demographic Characteristics and Liking Scores

Our findings reveals that there is no association between the liking scores and socio-demographic characteristics such as (age groups, and gender) (see **Tables 4.8 & Table 4.9)**. This means that the liking scores for both *focaccia* samples are not affected by neither age groups nor gender. However, this finding is not consistent with a former study performed by Nu et al., (1996) where it was confirmed that gender and age have a great impact on food preferences. In another former study, participated males showed a general preference for low calorie food compared to women. According to Nu and his colleagues, the gap between females and males widens when they grow older, especially regarding snacking. On the other hand, it seems that food repertoire increases during adolescence (Nu et al., 1996)

Table 4.8 Relationship between age groups and liking scores for both types of *focaccia* at different storage times.

	***Focaccia* with tomato &olive**				***Focaccia* with frozen onion &oregano**			
	Liking (60 d)	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**	**Liking (60 d)**	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**
< 25	5,140 a	5,689 a	6,079 a	5,395 a	4,854 a	4,867 a	5,215 a	4,822 a
>25	4,954 a	5,121 a	5,663 a	4,621 a	4,613 a	4,837 a	4,807 a	4,835 a
Pr > F	0.455	0.320	0.451	0.413	0.422	0.209	0.054	0.464
Significant	No	No	No	No	No	No	No	No

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to one-ANOVA test. d: Day.

Table 4.9 Relationship between gender and liking scores for both types of *focaccia* at different storage times.

	***Focaccia* with tomato &olive**				***Focaccia* with frozen onion &oregano**			
	Liking (60 d)	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**	**Liking (60 d)**	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**
Female	5,051 a	5,918 b	6,269 a	4,939 a	4,769 a	5,505 b	4,471 a	4,678 a
Male	5,043 a	4,892 a	5,473 a	5,077 a	4,697 a	4,199 a	5,551 a	4,980 a
Pr > F	0.455	0.320	0.451	0.413	0.422	0.209	0.054	0.464
Significant	No	No	No	No	No	No	No	No

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to one-ANOVA test. d: Day.

4.3.2. Physical Health Data

According to **Table 4.10**, only (3%) of consumers suffer from food intolerance (e.g. lactose intolerance) and only (10%) have food allergy for eggplant, cacao, pepper, mushroom, nuts, strawberries, and fruits. The results also reveal that the majority of consumers (66%) are non-smokers, whereas (13%) are irregular smokers, (13%) are regular smokers, and (8%) were former smokers.

Table 4.10 Consumers' Physical Health Status presented in frequencies (F) and percentages (%)

Variable	Frequency (F)	Percentage (%)
Food Intolerance		
Yes	3	3.0
No	96	96.9
Food Allergy		
Yes	10	10.1
No	89	89.9
Smoking Status		
Non-smoker	65	65.7
Former smoker	8	8.1
Irregular smoker	13	13.1
Regular smoker	13	13.1

4.3.2.1. Nutritional Status

Figure 4.8 shows that half of the participated consumers have a normal weight status, while the other consumers are classified as overweight, obesity, and underweight by 23%, 11%, and 4.5% , respectively.

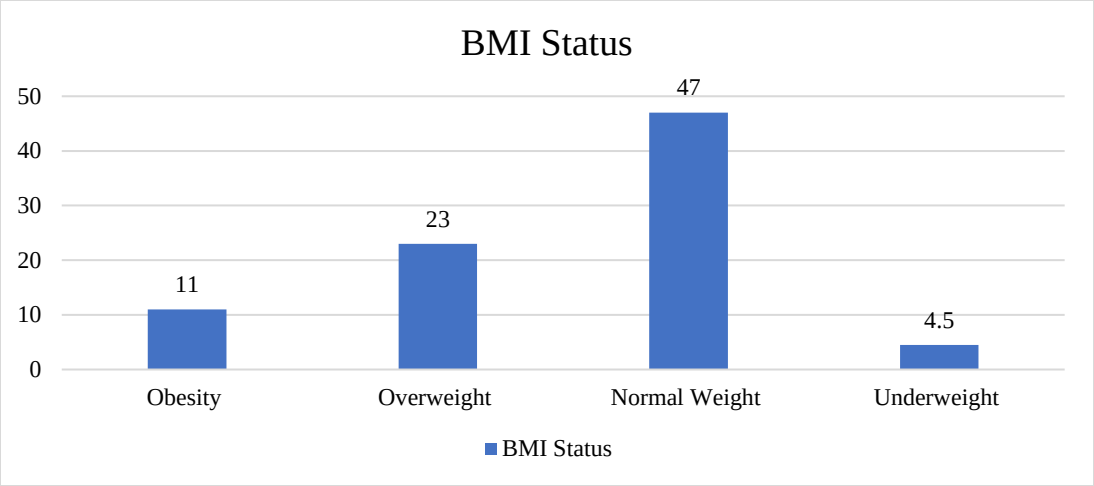


Figure 4.8 BMI classification among consumers

4.4. Sensory Evaluation: CATA

Once the commercial shelf life of the various types of *focaccia* has been determined it is important to establish, for each type of *focaccia*, what determines the acceptance of the product and what its refusal and identify which, among these, have a more significant influence, in order to have indications on how to act to slow down the decay of positive attributes and the development of negative ones. In this way, moreover, it is possible to understand whether these are properties associated with the production technology or the preservation of the product in the ATM and what interventions to hypothesize, that is if it is necessary to intervene on the process parameters, or on the formulation of the buns or on the kinetic development of the phenomena responsible for the alterations that occur.

4.4.1. *Focaccia* with Tomato & Olive (F1)

To describe the samples of *focaccia* with tomato &olive, 18 attributes were used. **Figure 4.9** shows the biplot of attributes and samples on the plane formed by the first two factors which represent 93.49% of the variance of the experimental data (correspondence analysis). The graph shows that there is no association between positive attributes and short storage times and, vice versa. Fresh samples “7 days” are characterized by the following negative attributes; raw dough, chewy, and unseasoned. It is revealed that storage for more than 45 days is correlated with negative attributes

(dry olive, rancidity, crisp border, oiliness). Surprisingly, storing samples for 30 days is correlated with positive attributes (e.g. typical *focaccia* odor and soft), and it is known that the intensity of these attributes deteriorates over time (Bhise & Kaur., 2014). These results are consistent with survival analysis data which showed that the time at which 50% of consumers consider the product unacceptable was 58 days of storage.

The survival analysis is supported by **figure 4.10** which confirm that the fresh the fresh samples (7 days) is liked as the same as the samples stored 60 for days. However, samples stored for 30 days storage is the most liked samples, even when compared to the fresh sample.

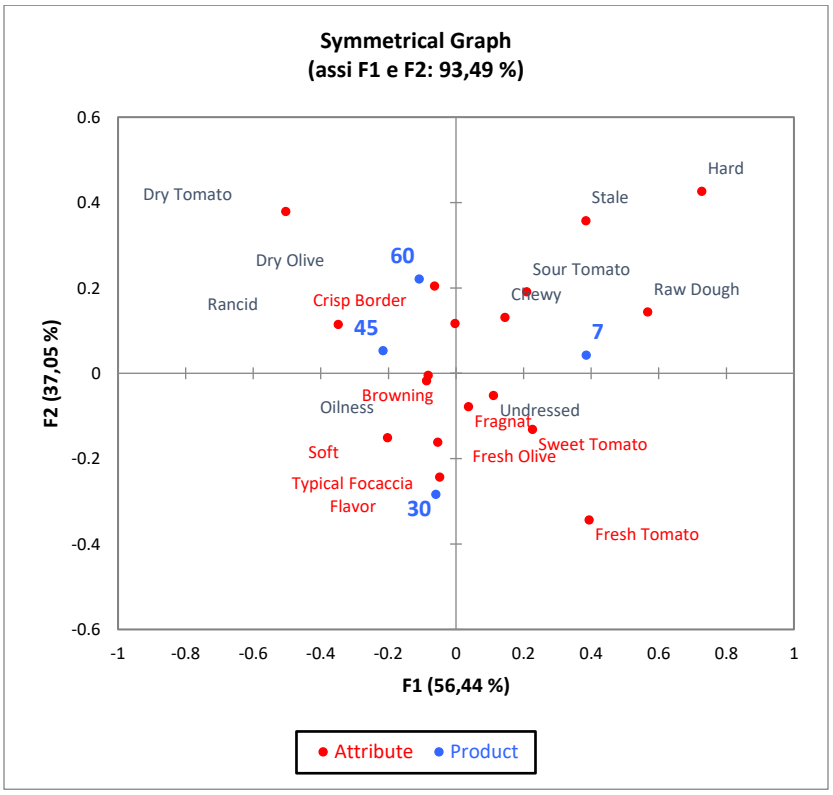


Figure 4.9 Corresponding analysis for sample F1 at different storage times

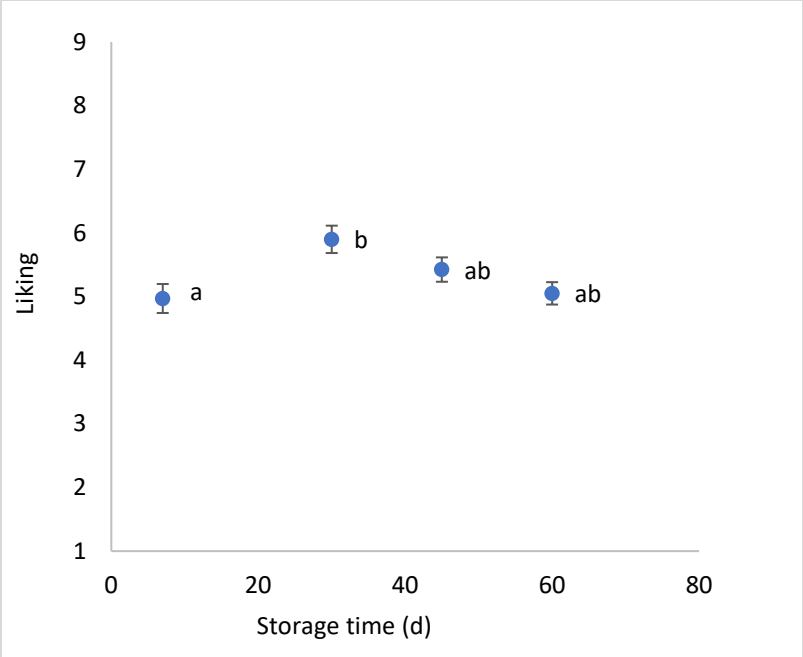


Figure 4.10 The liking scores of sample F1 at different storage times (average ± ES; N = 99).

Table 4.11 presents the frequencies that each attribute was indicated by consumers for sample (F1) at different storage times. Only significant attributes were reported. There was no statistical difference among samples ($p > 0.05$) for fragrant, rancid, chewy, crisp border, browning, dry olive, fresh olive, acid tomato, oiliness, and undressed. Therefore, those attributes cannot be pointed out as responsible for liking or disliking of the product.

Table 4.11 Cochran's Q test results for each attribute for sample F1 at different storage times.

	p-value	**7 d**	**30 d**	**45 d**	**60 d**
Stale	0.008	0,162 (b)	0,040 (a)	0,061 (ab)	0,121 (ab)
Soft	0.000	0,303 (a)	0,707 (c)	0,545 (bc)	0,465 (ab)
Raw Dough	0.006	0,162 (b)	0,051 (a)	0,051 (a)	0,061 (a)
Dry Tomato	0.000	0,051 (a)	0,101 (a)	0,323 (b)	0,283 (b)
Typical *focaccia* Flavor	0.001	0,253 (a)	0,444 (b)	0,283 (a)	0,212 (a)
Hard	0.002	0,121 (b)	0,010 (a)	0,020 (a)	0,061 (ab)
Sweet Tomato	0.034	0,273 (a)	0,242 (a)	0,162 (a)	0,131 (a)
Fresh Tomato	0.001	0,192 (c)	0,182 (bc)	0,071 (ab)	0,040 (a)

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to Cochran's Q test. d: Day.

Figure 4.11 reveals that liking of *focaccia* with tomato & olives is positively associated to the following positive attributes " soft, fragrant, crisp border, browning, typical *focaccia* flavor, fresh

olive, sweet tomato, and fresh tomato", and is negatively associated to the following negative attributes "stale, chewy, dry tomato, dry olive, sour tomato, and hard". According to **figure 4.12**, the negative attributes "chewy, undressed, and dry olive" significantly affect the liking scores of *focaccia* with tomato &olive by a mean of -1.83, -1.25, and -0.80, respectively. Whereas the positive attributes "sweet tomato, crisp border, browning, typical odor flavor, and soft" significantly affect the liking scores by a mean of +1.07, +1.29, +1.65, +1.74, and +1.80, respectively.

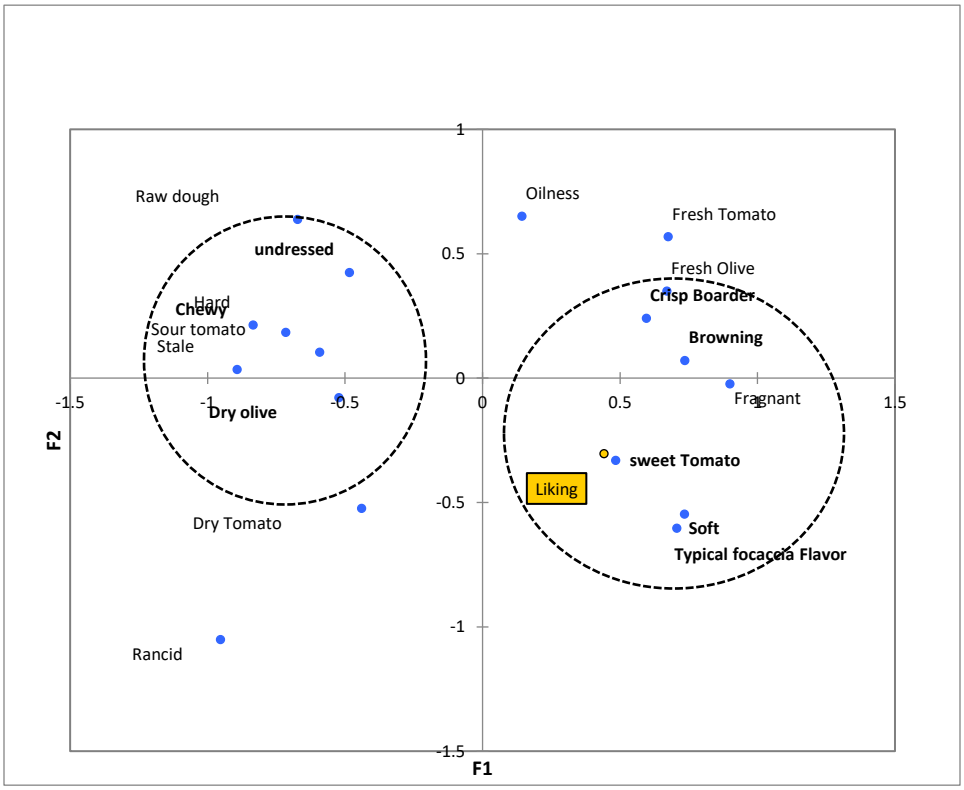


Figure 4.11 Principal Coordinate Analysis associating data from CATA test and liking of sample F1.

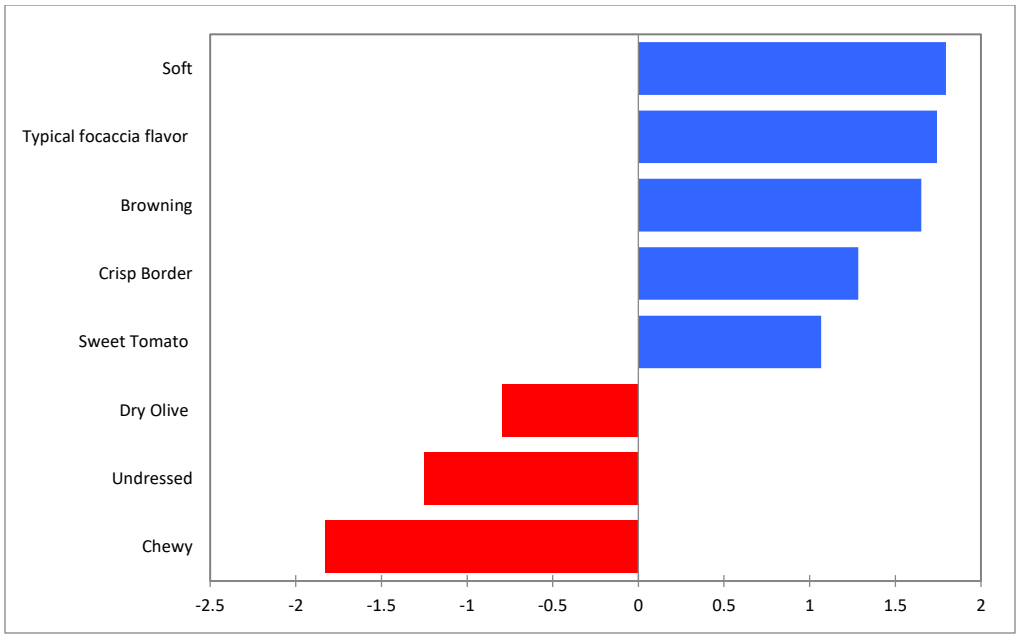


Figure 4.12 Mean impact of positive and negative attributes on the liking scores of sample F1

Figure 4.13 illustrates the impact of each sensory attribute on the variation of the liking as a function of percentage (%). It was found that the presence of the following attributes "soft, crisp border, browning, typical *focaccia* flavor and sweet tomato" can significantly affect the liking scores. These attributes have a positive effect on *focaccia* samples and so they are considered as a must-have" for this kind of product. **Table 4.12** shows that the presence of these attributes within percentage ranging from 20% to 51%, improves the rating about 1-1.7 points on the 9-point hedonistic scale. On the other hand, the following attributes "chewy, dry olive, and undressed" are considered as a "must not have", as they have a negative effect on the sample. **Table 4.12** reveals that these attributes were found within a low percentage of 20%, and as a result of this, the rating score was reduced by 20%. Their presence could worsen the liking rating by about 1-1.8 points on the hedonic scale. And it is clear that negative attributes present in a frequency lower than the positive ones

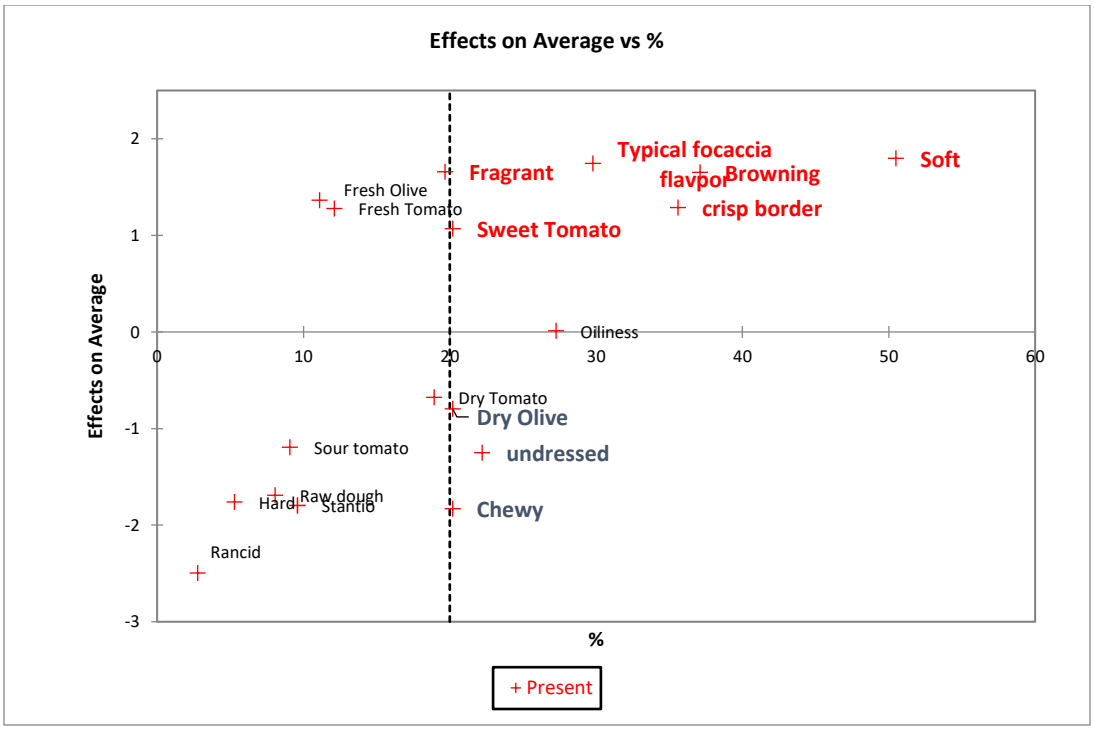


Figure 4.13The presence of sensory attributes and its effect on the liking of sample F1

Table 4.12 The presence of sensory attributes and its effect on the liking of sample F1

Attribute	Level	Frequency	Percentage %	Sum (liking)	Average (liking)	Effect on media	p-value*
Stale	Absent	358	90.40%	1972.000	5.508		
	Present	38	9.60%	141.000	3.711	-1.798	
Soft	Absent	196	49.49%	868.000	4.429		
	Present	200	50.51%	1245.000	6.225	1.796	**< 0,0001**
Fragrant	Absent	318	80.30%	1593.000	5.009		
	Present	78	19.70%	520.000	6.667	1.657	
Rancid	Absent	385	97.22%	2081.000	5.405		
	Present	11	2.78%	32.000	2.909	-2.496	
Chewy	Absent	316	79.80%	1803.000	5.706		
	Present	80	20.20%	310.000	3.875	-1.831	**< 0,0001**
Crisp Border	Absent	255	64.39%	1244.000	4.878		
	Present	141	35.61%	869.000	6.163	1.285	**< 0,0001**
Raw dough	Absent	364	91.92%	1992.000	5.473		
	Present	32	8.08%	121.000	3.781	-1.691	
Browning	Absent	249	62.88%	1176.000	4.723		
	Present	147	37.12%	937.000	6.374	1.651	**< 0,0001**
Dry tomato	Absent	321	81.06%	1754.000	5.464		
	Present	75	18.94%	359.000	4.787	-0.678	
Typical *focaccia* flavor	Absent	278	70.20%	1339.000	4.817		
	Present	118	29.80%	774.000	6.559	1.743	**< 0,0001**
Dry olive	Absent	316	79.80%	1737.000	5.497		
	Present	80	20.20%	376.000	4.700	-0.797	**0.000**
Fresh olive	Absent	352	88.89%	1825.000	5.185		
	Present	44	11.11%	288.000	6.545	1.361	
Sour tomato	Absent	360	90.91%	1960.000	5.444		
	Present	36	9.09%	153.000	4.250	-1.194	
Hard	Absent	375	94.70%	2036.000	5.429		
	Present	21	5.30%	77.000	3.667	-1.763	
Oiliness	Absent	288	72.73%	1536.000	5.333		
	Present	108	27.27%	577.000	5.343	0.009	**0.964**
Sweet tomato	Absent	316	79.80%	1618.000	5.120		
	Present	80	20.20%	495.000	6.188	1.067	**< 0,0001**
undressed	Absent	308	77.78%	1729.000	5.614		
	Present	88	22.22%	384.000	4.364	-1.250	**< 0,0001**
Fresh tomato	Absent	348	87.88%	1803.000	5.181		
	Present	48	12.12%	310.000	6.458	1.277	

*P-value < 0.05 is significant.

4.4.2. Focaccia with Frozen Onion & Oregano (F2)

To describe the samples of *focaccia* with frozen onion & Oregano, 14 attributes were used. **Figure 4.14** shows the biplot of attributes and samples on the plane formed by the first two factors which represent 78.86% of the variance of the experimental data (correspondence analysis). Fresh samples (7 days) were characterized by "onion taste, and sweet" which is considered to be a positive attribute. Samples stored for 30 days were characterized by the negative attribute "bitter". Surprisingly, samples stored for 45 days were correlated with positive attributes "browning, soft, and fragrant" which is normally deteriorate during prolonged periods of storage. The figure also shows that storing samples for 60 days was more correlated with the negative attribute "dry, rancid, oiliness, and stale" and this was expected because the intensity of negative attributes normally increases during prolonged storage periods. These results also are in agreement with the survival analysis data which showed that the time at which 50% of consumers considered the product unacceptable was 61 days of storage.

It was also observed that the liking scores for sample F2 remains constant over time for the entire storage period; therefore, there are no significant differences between the fresh sample (7 days) and the sample after 60 days of storage **(Figure 4.15)**.

Table 4.13 shows the frequencies that each attribute was indicated by consumers for sample (F2) at different storage times. Only significant attributes were reported. There was no statistical difference among samples ($p > 0.05$) for rancid, chewy, bitter, oiliness, dry, crisp border, browning, fragrant, and sweet. Therefore, those attributes cannot be pointed out as responsible for liking or disliking of the product.

Table 4.13 Cochran's Q test results for each attribute for sample F2 at different storage times.

Attribute	p-value	7 d	30 d	45 d	60 d
Stale	0.048	0,091 (ab)	0,111 (ab)	0,040 (a)	0,152 (b)
Pungent Onion Taste	0.018	0,192 (a)	0,182 (a)	0,071 (a)	0,091 (a)
Hard	0.000	0,051 (a)	0,141 (b)	0 (a)	0,071 (ab)
Onion taste	0.047	0,475 (b)	0,404 (ab)	0,374 (ab)	0,283 (a)
Soft	0.005	0,444 (b)	0,263 (a)	0,434 (ab)	0,485 (b)

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to Cochran's Q test. d: Day.

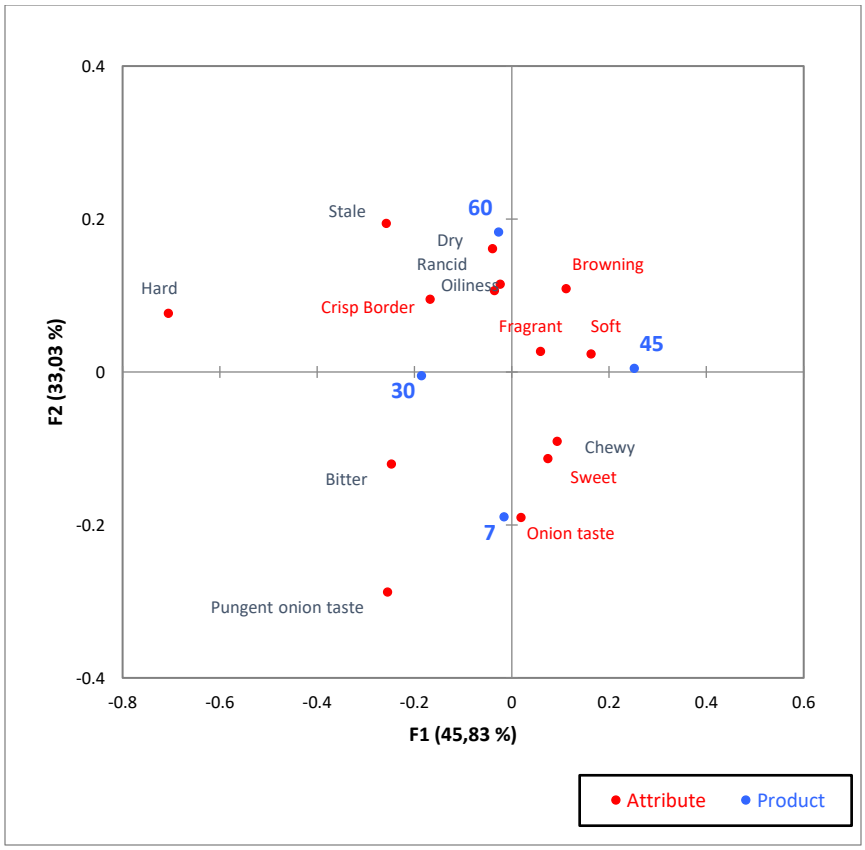


Figure 4.14 Corresponding analysis for sample F2 at different storage times.

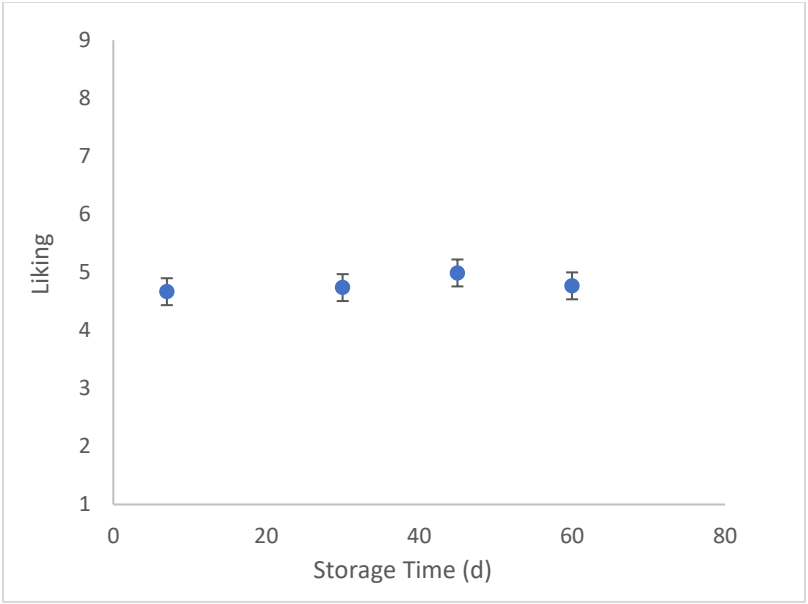


Figure 4.15 The liking scores of sample F2 at different storage times (average ± ES; N = 99).

Figure 4.16 shows that liking scores for *focaccia* with frozen onion &oregano is positively associated to the following attributes “crisp border, browning, onion taste, fragrant, soft, sweet, and oiliness”, and is negatively associated to the following negative attributes “dry, stale, chewy, bitter, and pungent onion taste”. According to **figure 4.17**, the negative attributes “chewy, and dry” significantly affect the liking scores of *focaccia* with frozen onion &oregano by a mean of -1.60, and -1.46, respectively. Whereas the positive attributes “crisp border, sweet, onion taste, browning, and soft” significantly affect the liking scores by a mean of +0.93, +1.00, +1.42, +1.66, and +1.67, respectively.

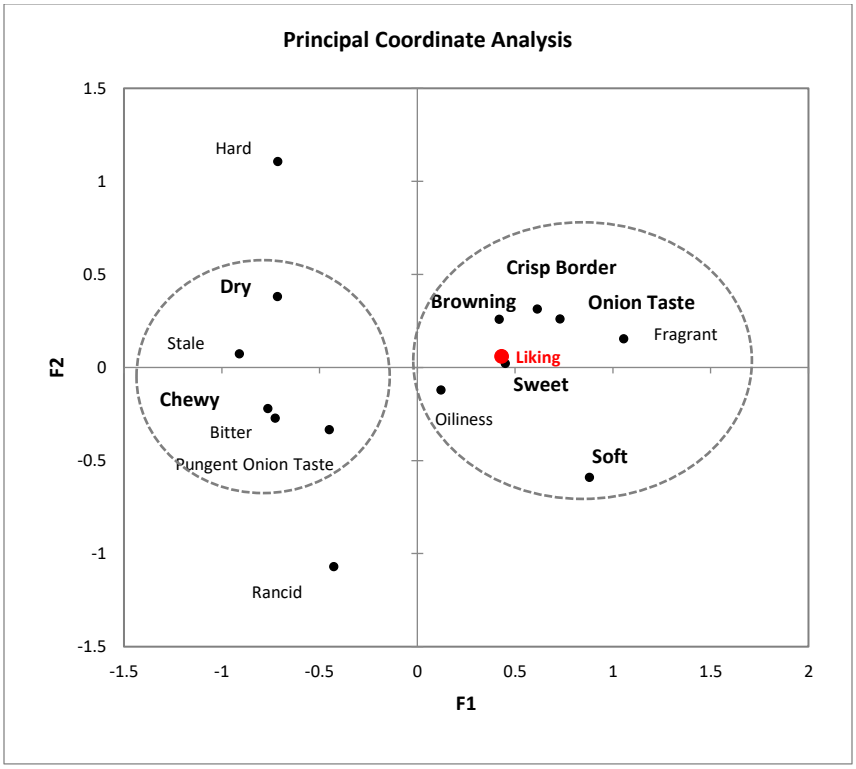


Figure 4.16 Principal Coordinate Analysis associating data from CATA test and liking of sample

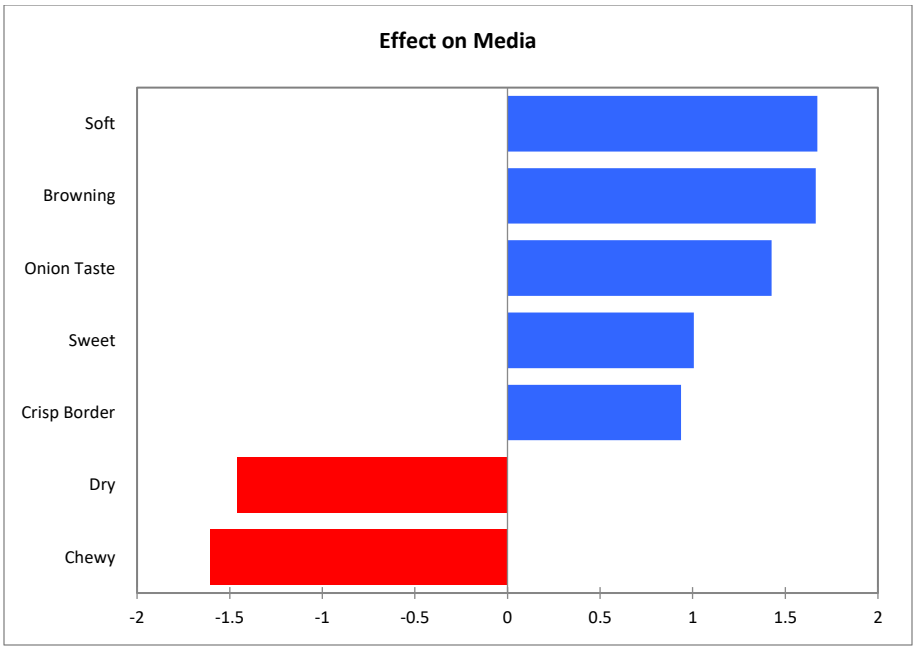


Figure 4.17 The mean impact of positive and negative attributes on the liking scores of sample F2

Figure 4.18 illustrates the impact of each sensory attribute on the variation of the liking as a function of percentage (%) with which it was selected by consumers. It was found that the presence of the following attributes "browning, sweet, soft, onion taste, and crisp border" can significantly modify the liking scores. Most of these attributes have a positive effect on *focaccia* samples and so they are considered as a "must have" in the product. The results also reveal that the presence of these attributes within percentage ranging from 28% (sweet) to 41% (soft), their presence improves the rating of about 1-2 points on the 9-point hedonistic scale. On the other hand, the following negative attributes "dry and chewy" are considered as a "must not have" in the product as they have negative effect on the sample. These negative attributes were found within a low percentage ranging from 22% to 27%, respectively. The presence of these attributes worsens the judgment approval of about 1.5 points on the hedonistic scale. As with first type of *focaccia*, we found that the negative attributes have a lower frequency than the positive ones. **Table 4.14** illustrates the presence of sensory attributes and its effect on the liking of *focaccia* with frozen onion &oregano.

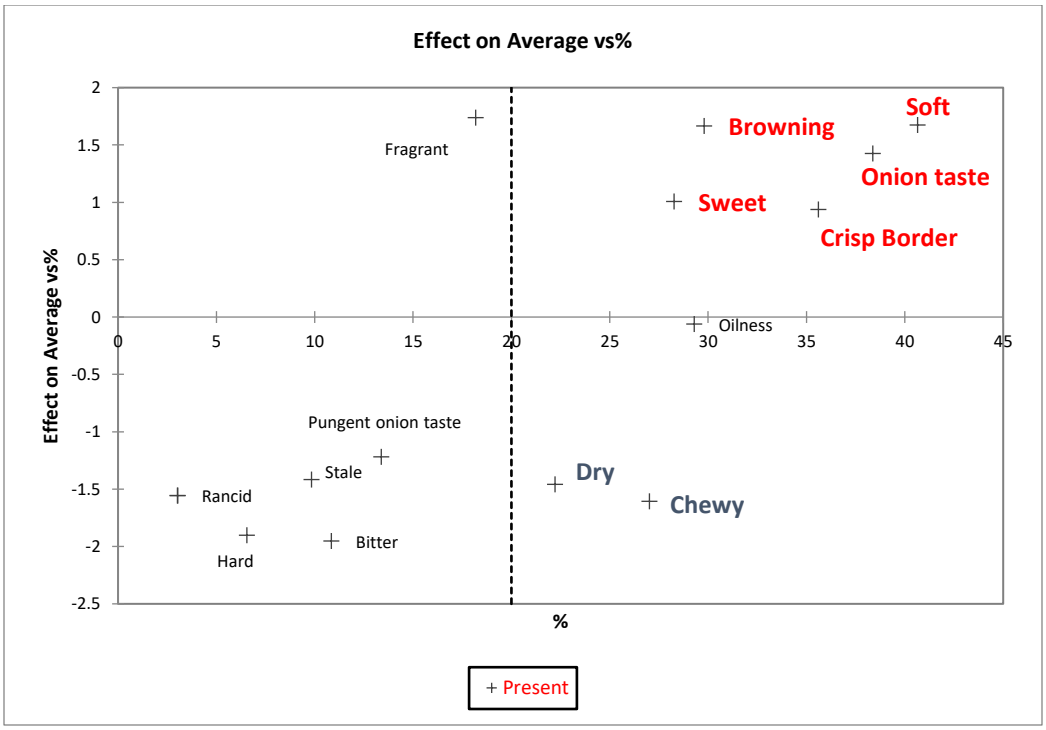


Figure 4.18 The presence of sensory attributes and its effect on the liking score of sample F2

Our CATA findings were consistent with a former study performed by Volpe et al., (2018) CATA method was used to evaluate sensory perception of two formulations of frozen butter croissant during different storage times (3, 7, 16, 20, 23 and 27 hours). At the end of that study, it was noted significant differences among samples in terms of both negative (stale, hard, dry) and positive (soft, fresh) attributes, and, as expected, frequency of use of the positive attributes decreased with storage time, whereas the contrary occurred for the negative ones. This proves that the CATA method is a valid method to evaluate sensory characteristics of products stored at different storage times.

Table 4.14 The presence of sensory attributes and its effect on the liking of sample F2

Attribute	Level	Frequency	Percentage %	Sum (Liking)	Media (Liking)	Effect on media	p-value
Rancid	Absent	384	96.97%	1750.000	4.557		
	Present	12	3.03%	36.000	3.000	-1.557	
Stale	Absent	357	90.15%	1660.000	4.650		
	Present	39	9.85%	126.000	3.231	-1.419	
Chewy	Absent	289	72.98%	1429.000	4.945		
	Present	107	27.02%	357.000	3.336	-1.608	**< 0,0001**
Pungent Onion Taste	Absent	343	86.62%	1603.000	4.673		
	Present	53	13.38%	183.000	3.453	-1.221	
Bitter	Absent	353	89.14%	1667.000	4.722		
	Present	43	10.86%	119.000	2.767	-1.955	
Oiliness	Absent	280	70.71%	1268.000	4.529		
	Present	116	29.29%	518.000	4.466	-0.063	
Dry	Absent	308	77.78%	1489.000	4.834		
	Present	88	22.22%	297.000	3.375	-1.459	**< 0,0001**
Hard	Absent	370	93.43%	1715.000	4.635		
	Present	26	6.57%	71.000	2.731	-1.904	
Onion Taste	Absent	244	61.62%	967.000	3.963		
	Present	152	38.38%	819.000	5.388	1.425	**< 0,0001**
Soft	Absent	235	59.34%	900.000	3.830		
	Present	161	40.66%	886.000	5.503	1.673	**< 0,0001**
Crisp Border	Absent	255	64.39%	1065.000	4.176		
	Present	141	35.61%	721.000	5.113	0.937	**< 0,0001**
Browning	Absent	278	70.20%	1116.000	4.014		
	Present	118	29.80%	670.000	5.678	1.664	**< 0,0001**
Fragrant	Absent	324	81.82%	1359.000	4.194		
	Present	72	18.18%	427.000	5.931	1.736	
Sweet	Absent	284	71.72%	1200.000	4.225		
	Present	112	28.28%	586.000	5.232	1.007	**< 0,0001**

*P-value < 0.05 is significant

4.5. Consumer Sensitivity

Since the storage time did not affect the liking scores for both types of *focaccia*, the second aim of this thesis was to find whether consumer sensitivity could affect the liking scores for *focaccia* samples at different storage time. Therefore, we measured their sensitivity according to their taste, odor, and texture. **Table 4.15** shows consumers characteristics according to their sensitivities.

Table 4.15 Consumers characteristics according to their sensitivities

	Low Sensitivity / Non-taster	**Medium Sensitivity/ Medium taster**	**High Sensitivity/ Super-taster**
Oral Sensitivity	39	36	24
Odor Sensitivity	27	47	25
Texture Sensitivity	46	22	31

4.5.1. PROP Status

Based on the theoretical distribution of haplotypes, the percentile distribution of ratings was computed. The upper limit of the first quartile and lower limit of the third quartile were 21.5 and 57 on gLMS, respectively. These values are in good agreement with the arbitrary cut-offs used in previous studies to categorize subjects in Non-Taster (arbitrary cut-off gLMS<moderate, 21.5) and Super Taster (arbitrary cut-off gLMS> very strong, 57.5) (Hayes et al., 2010). Twenty-seven consumers were classified as PROP nontasters, 47 as medium tasters, and 25 as supertasters.

4.5.1.1. PROP Status &Liking Scores

The results reveal that PROP status has no significant effect on the liking score (**Table 4.16**). Our result is consistent with the results reported by Pasquet et al. (2002), Ludy & Mattes (2012), and Tepper et al. (2009), who also confirmed that taster status is not correlated with the perceptions of bitter foods. However, our findings contradict former researches perforemed by Drewonowski et al. (1999), Bell &Tepper (2006), Dinehart et al. (2006), Tepper (2008), and Duffy et al. (2010). One possible reason for the variability in findings is that most of these researches examined food choice, hedonic ratings, or sensory perceptions related to bitter foods but not self-reported food preferences.

Obviously, sensitivity to PROP bitterness was not a usefull predictor of food preferences of our sample. Food preferences are formed by various factors such as familiarity, observational learning, and cultural attitudes. Learning and culture drive us to evolve liking and familiarity for foods that will not be portended based on our sensitivity to PROP. The role of observational learning, classical conditioning, and precocious exposure to bitter and strong flavors may be more significant than genetic taste sensitivty in forming our cognitive interpretation of the sensory experience of taste perception. We may do not like to try bitter flavors, however, through an attempt we may decide that we prefer and like those bitte flavors. How and wether these preferences are gained possibly is linked with cultural and family dynamics that result in duplicated exposures and positive clarification of a food's texture, flavor, and other properties (Catanzaro et al. 2013).

Table 4.16 Relationship between PROP status and liking scores for both types of *focaccia* at different storage time

	***Focaccia* with tomato &olive**				***Focaccia* with frozen onion &oregano**			
	Liking (60 d)	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**	**Liking (60 d)**	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**
NT	5,291 a	5,670 a	5,828 a	5,181 a	4,775 a	4,919 a	5,709 a	5,028 a
ST	5,395 a	5,313 a	6,225 a	4,506 a	4,851 a	4,838 a	4,854 a	4,703 a
MT	4,456 a	5,232 a	5,560 a	5,336 a	4,574 a	4,798 a	4,470 a	4,755 a
Pr > F	0.455	0.320	0.451	0.413	0.422	0.209	0.054	0.464
Significant	No	No	No	No	No	No	No	No

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to one-ANOVA test. d: Day.

4.5.2. Odor Sensitivty

Our results reveals that thirty-nine consumers were classified as low sensitive, 36 as medium sensitive, and 25 as high sensitive.

4.5.2.1. Odor Sensitivity &Liking Scores

Our findings reveals that odor sensitivity has no significant effect on the liking score (**Table 4.17**). Former studies on the influence of olfactory cues on food choices, and intake, are controversial (De Wijk &Zijlstra., 2012; Fedoroff et al., 1997; Gaillet-Torrent et al., 2014; Gaillet et al., 2013; Larsen et al., 2012; Ramaekers et al. 2014; Zoon et al., 2014). While Zoon et al. (2014) reported that there is no impact of (clearly detectable) odor exposure on food choices, new French studies,

in accordance with De Wijk &Zijlstra. (2012) found that ambient exposure to (unaware) fruity odors increased congruent food choice during a subsequent lunch (Chambaron et al., 2015; Gaillet-Torrent et al., 2014; Gaillet et al., 2013). They suggest that this operates through priming, thereby implying that the odor needs to be unattended or subthreshold in order to exert its influences (Smeets &Dijksterhuis., 2014), as much decision making occurs at a nonconscious level (Ko¨ster., 2009). Moreover, the French findings also imply that (unattended) odors may not only signal a specific food or macronutrient category, but also prime a certain context in which the product is most commonly eaten (e.g., appetizer, dessert, and lunch) (Chambaron et al., 2015; Gaillet-Torrent et al., 2014; Gaillet et al., 2013).

Table 4.17 Relationship between odor sensitivity and liking scores for both types of *focaccia* at different storage time

	***Focaccia* with tomato &olive**				***Focaccia* with frozen onion &oregano**			
	Liking (60 d)	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**	**Liking (60 d)**	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**
LS	5,277 a	5,502 a	6,281 a	4,622 a	5,114 a	4,554 a	4,760 a	5,101 a
MS	4,880 a	5,860 a	5,975 a	4,807 a	4,795 a	5,377 a	5,537 a	4,593 a
HS	4,984 a	4,853 a	5,358 a	5,595 a	4,290 a	4,625 a	4,737 a	4,792 a
Pr > F	0.455	0.320	0.451	0.413	0.422	0.209	0.054	0.464
Significant	No	No	No	No	No	No	No	No

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to one-ANOVA test. d: Day.

4.5.3. Hardness Sensitivity

Based on two criteria, the consumers were clustered into three group. The first group was formed by considering two criteria: angular coefficient greater than or equal to 3.125 and any value of R2; angular coefficient between 1.150 and 3.125 and with an R2 greater than or equal to 0.785. This group was made up of 32 consumers who are able to discriminate the four jellies at different concentrations of gelling agent, therefore characterized by a high sensitivity to hardness (HS).

The second group was formed taking into consideration two criteria: angular coefficient less than or equal to 0 and any value of R2; angular coefficient greater than 0 and less than 1.150 with an R2 less than or equal to 0.4. This group was made up of 46 subjects who were not at all able to discriminate between the samples, therefore characterized by a low sensitivity to hardness (LS).

Finally, the rest of consumer were considered as having a medium sensitivity to hardness (MS)

4.5.3.1. Hardness Sensitivity &Liking Scores

Our findings reveals that hardness sensitivity has no significant effect on the liking score **(Table 4.18**). In other words, this means that whether the consumer is classified as LS or HS, he will perceive the product in the same way. No former studies addressing the effect of hardness sensitivity on food were found. Our explanation for these findings is that Oropan company, which provided us with *focaccia* samples, have already made improvements to their product quality as response to a preliminary study conducted by sensory labaratories of Naples on January 2019. As the preliminary study found that *focaccia* samples has problems related to storage time, for instance samples stored for more than 30 days were not liked by the consumers.

Table 4.18 Relationship between hardness sensitivity and liking scores for both types of *focaccia* at different storage time

	***Focaccia* with tomato &olive**				***Focaccia* with frozen onion &oregano**			
	Liking (60 d)	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**	**Liking (60 d)**	**Liking (45 d)**	**Liking (30 d)**	**Liking (7 d)**
LS	5,361 a	5,093 a	5,744 a	5,302 a	4,143 a	4,499 a	5,010 a	4,927 a
MS	4,423 a	5,609 a	6,243 a	4,159 a	4,816 a	4,975 a	4,922 a	4,820 a
HS	5,358 a	5,513 a	5,626 a	5,563 a	5,241 a	5,082 a	5,102 a	4,739 a
Pr > F	0.455	0.320	0.451	0.413	0.422	0.209	0.054	0.464
Significant	No	No	No	No	No	No	No	No

*Same letters in a row indicate there is no statistical difference among samples at 5% significance level according to one-ANOVA test. d: Day.

4.6. Limitations

Some limitations of this study should be mentioned. First, the total number of the participated consumers might be not representative for a larger population. Because when we divided consumers into groups according to their sensitivities, each group consisted from a limited number of consumers. Second, the study did not consider that food preference and liking is affected by factors other than consumers sensitivities. For instance; food choices and preferences are affected by personality traits (e.g. food neophobia and food involvement) and psychological traits (Eertmans et al., 2005). We recommend that the current study should be followed up with larger numbers of consumers; future studies should also assess participants' psychological and personality traits by using various measures and scales including; food involvement scale (FIS) (Bell &Marshall., 2003), food neophobia scale (FNS) (Pliner & Hobden., 1992) and Dutch eating

behavior questionnaire (DEBQ) (Van Strien et al.,1986). Future studies could also include other storage times

5. Conclusion

At the end of the study, the shelf life was estimated as the storage time that corresponded to 50% consumers rejection in 58 ±6 d, and 61±5 d, respectively for samples F1 and F2. For sample F1, CATA questions results showed that there are significant differences for both negative attributes (stale, dry tomato, hard, raw dough) and positive attributes (soft, typical focaccia flavor, sweet tomato, fresh tomato). For sample F2, also, CATA questions results showed that there are significant differences in terms of both negative (stale, hard, onion taste) and positive (soft, pungent onion taste) attributes. For both types of samples, it was further reported that fresh samples were liked by the consumers as those stored for 60 days. This research has also confirmed that the CATA method can be used to characterize product during different storage times. Moreover, it is concluded that using CATA in combination with macroscopic techniques is considered a valid method to characterize food product stored at different storage times.

Our research also indicates that that liking scores by the consumers for both types of focaccia are not affected by either socio-demographic variables (age and gender) or consumer sensitivity. Food preference and liking is affected by factors other than consumers sensitivities, thus, future studies should also assess consumers' psychological and personality traits.

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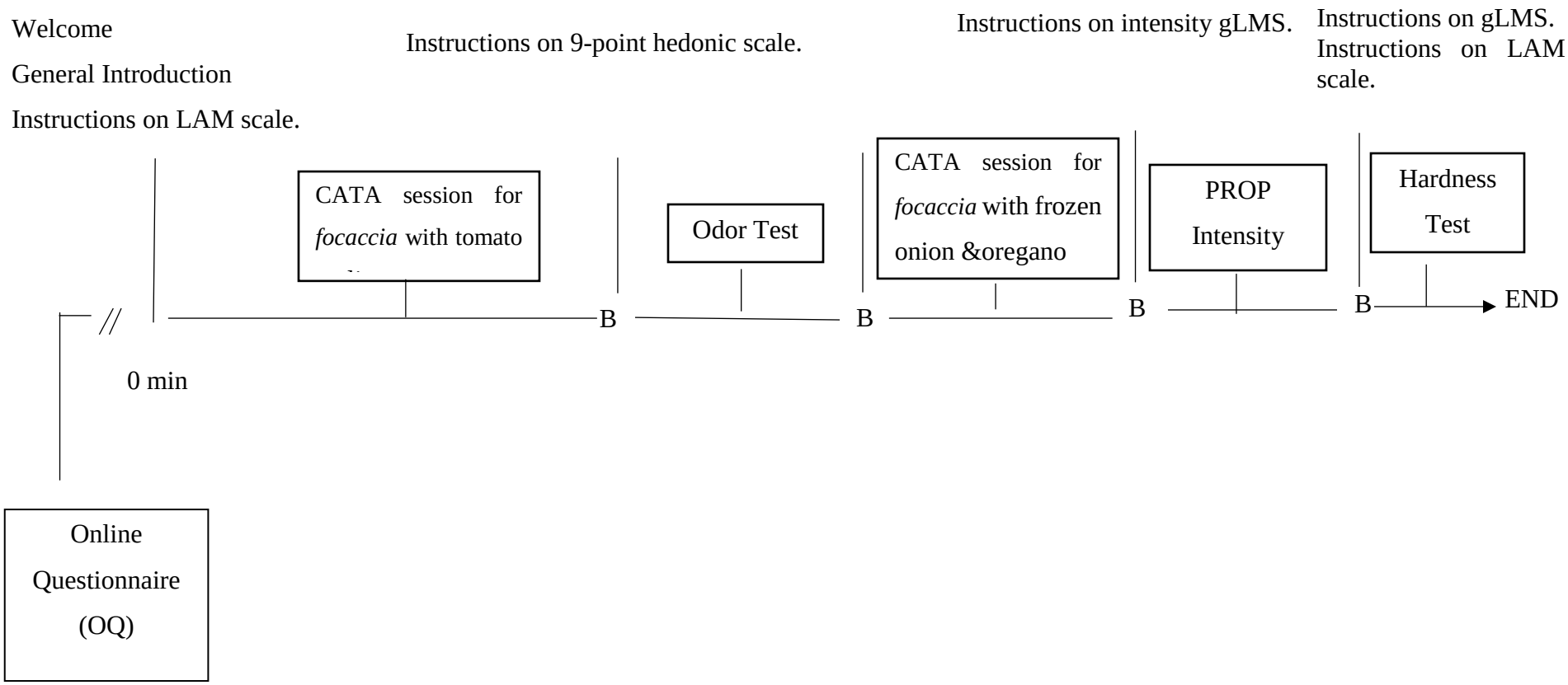
Appendix

A. Diagram of Data Collection



B. Online Questionnaire

Variable	Option
Liking	
1 Item -6 categories	Never consumed/ Extremely disliked /Very disliked /Moderately disliked /Slightly disliked /Neither liked nor disliked/Slightly liked /Moderately liked /Very liked /Extremely liked
Frequency of Consumption	
1 Item- 5 categories	Less once a month/1-2 times per month/ 3 times per month/ Once a week/ 2 times per week/ Nearly every day/ Everyday
Preferences	
4 Items	(1= most preferred/ 4= least preferred)
Socio-demographic data	
Age (self-reported)	Years old at the moment of the test
Gender	M/F
Place of birth	Province*
Educational level	None/Primary/Lower secondary/Upper secondary/Degree/Post-degree
Marital Status	Married/Divorced /widowed/Single
Employment status	Housewife/Student/Retired/Unemployed /Farmer/freelance professional/Trader or artisan/Employer

Physical health data	
Weight (self-reported)	kg*
Height (self-reported)	cm*
Smoking status	Non-smoker/ Former smoker/ Smoking occasionally/ Smoking usually
Food allergies	Yes/No; if yes, which one*
Food intolerances	Yes/No; if yes, which one*

The options were displayed as check the one/s that apply, if not differently specified.

*Indicates that the question was open-ended.

C. Hedonic and sensory responses to food products and odors aims, samples and rating scales

Stimuli	Response	Aim	Samples	Rating scale
Odors	Liking	To measure individual differences in liking for odors	4 Samples: - Onion - Garlic. - Peach - Honey	Liking: 9-point scale (extremely dislike/ extremely like).
	Sensory	To measure individual differences in odor responsiveness	4 Samples: - Onion - Garlic. - Peach - Honey	Identification: multiple choice Intensity: 9-point scale (extremely week/extremely strong) Irritation: 9-point scale (not at all irritant/extremely irritant)
Candies Sensory	Liking	To measure individual differences in liking for candies	4 samples of candies containing: - 3% agar - 5% agar - 7% agar - 9% agar	Liking: LAM scale (0-100)

	Sensory	To measure individual differences in hardness responsiveness	4 samples of candies containing: - 3% agar - 5% agar - 7% agar - 9% agar	Hardness: gLAM scale (0-100)
PROP	Sensory	To measure individual differences in bitterness responsiveness	2 samples of PROP solution.	Bitterness: gLAM scale (0-100)

D. Attribute list (Italian language)

1. 1. Si prega di controllare tutte le parole o le frasi che meglio descrivono la *focaccia* con pomodoro e olive: -

☐ Stantio	☐ Olive secche
☐ Morbido	☐ Olive fresche
☐ Fragrante	☐ Pomodoro acido
☐ Rancido	☐ Duro
☐ Gommoso	☐ Oleoso
☐ Bordo croccante	☐ Pomodoro dolce
☐ Dorato	☐ scondito
☐ Pomodori secchi	☐ Pomodori fresch
☐ Sapore di impasto crudo	☐ Tipico odore *focaccia*

2. Si prega di controllare tutte le parole o le frasi che meglio descrivono la *focaccia* con cipolla e origano: -

☐ Rancido	☐ Morbido
☐ Stantio	☐ Bordo croccante
☐ Gommoso	☐ Dorato
☐ Sapore di cipolla pungente	☐ Fragrante
☐ Amaro	☐ Dolce
☐ Oleoso	☐ Duro
☐ Secco	☐ Sapore di cipolla

E. Attribute list (English translation)

1. Please check all the words or phrase that best describe *focaccia* with tomato &olives:

☐ Stale	☐ Soft
☐ Rancid	☐ Fragment
☐ Chewy	☐ Crisp border
☐ Raw dough	☐ Browning
☐ Dry tomato	☐ Typical *focaccia* flavor
☐ Dry olive	☐ Fresh olive
☐ Sour tomato	☐ Fresh tomato
☐ Undressed	☐ Oiliness
☐ Hard	☐ Sweet tomato

2. Please check all the words or phrase that best describe *focaccia* with onion &oregano:

☐ Bitter	☐ Browning
☐ Chewy	☐ Soft
☐ Dry	☐ Fragrant
☐ Hard	☐ Stale
☐ Oiliness	☐ Sweet
☐ Pungent Onion taste	☐ Crisp border
☐ Rancid	☐ Onion taste

F. Abbreviation

CATA	Check all that apply
CNS	Central Nervous system
DEBQ	Dutch Eating Behavior Questionnaire
FNS	Food Neophobia Scale
FP	Flavor profile®
HS	High sensitive
JAR scales	Just-about-right scales
LS	Low sensitive
MS	Medium sensitive
MT	Medium taster
NT	Non-taster
PROP	6-n-Propylthiouracil
P-value	Probability value
QDA	Quantitative descriptive analysis®
ST	Super taster
TP	Texture profile®
TPA	Texture profile analyzer

جامعة نابولي فيدريكو الثاني

دائرة العلوم الزراعية

و

جامعة النجاح الوطنيّة

عمادة الدراسات العليّا

درجة الماجستير في

علوم وتكنولوجيا الغذاء

و

التّغذية وتكنولوجيا الغذاء

حساسيّة المستهلك وتقييم نضارة منتجات المخابز

إعداد

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الملخص

الفوكاشا هو خبز نموذجي في إيطاليا، وهو محل تقدير كبير لخصائصه الحسية وله سوقه الخاص. سبب تدهور الجودة أثناء التخزين يرجع بشكل رئيسي إلى الأحداث التدهورية المختلفة التي تشمل فقدان الصلابة المرتبطة بنشاط المياه عالية، واستعادة النشا وأكسدة الدهون. يؤثر فقدان الحداثة في منتجات المخابز سلبًا على إعجاب المستهلك وجودة المنتج. إن إدراك نضارة الطعام أثناء فترة صلاحيته يعتمد على كل من الخصائص الحسية للطعام وقدرة المستهلك على إدراك التدهور الحسي. يختلف المستهلكون في قدراتهم على إدراك الأذواق والأنسجة، وقد تؤدي اختلافات الإدراك هذه إلى تفضيلات مختلفة. يمكن استخدام الأساليب الحسية لفهم الحساسية الفردية للمستهلكين. الغرض الرئيسي من هذا البحث هو تقييم إدراك المستهلك لعينات الفوكاشيا المخزنة في أوقات مختلفة واستكشاف ما إذا كان هناك ارتباط بين حساسية المستهلك وإدراك عينات الفوكاشيا. في هذا البحث، تمت دراسة نوعين من الفوكاشا (النوع الأول: فوكاشا مزيّنة بالطماطم والزيتون (F1)، والنوع الثاني: فوكاشا مزينة بالبصل المجمد مع الزعتر (F2)). تم تخزين جميع العينات لمدة 7 و 15 و30 و 60 يومًا عند 20 درجة مئوية. تم تقييم حساسية المستهلك للذوق والرائحة والملمس باستخدام اختبار PROP وا أقلام الرائحة واختبار الصلابة على التوالي. تم استخدام توزيع Weibull لوصف وظيفة الرفض. تم استخدام طريقة CATA لتحديد الصفات الحسية لعينات الفوكاشيا. شارك تسعة وتسعون مستهلك في اختبار المستهلك. طُلب من المستهلكين تناول كل عينة من الفوكاشيا والإجابة على السؤال التالي: "هل عادة تستهلكين / تشترين الفوكاشا؟ نعم أم لا؟". طُلب منهم أيضًا اختيار أكثر السمات ملاءمة التي يمكن أن تصف العينات ومن ثمّ طلب من المستهلكين، تقييم مدى رضاهم باستخدام مقياس 10 سم يرتكز على "أكثر الأشياء غير السارة التي يمكن تخيلها" إلى "أكثر السعادة التي يمكن تخيلها". عندما تم إجراء تحليل survival analysis،

لوحظ أن نسبة القبول للعينات المخزنة لمدة 60 يومًا كانت أعلى قليلاً للعينات F2 (50٪) مقارنة بـ (47٪) للعينات F1. تم تقدير مدة الصلاحية كمدة التخزين التي تتوافق مع قبول المستهلكين بنسبة 50 ٪ في 58 ± 6 يوم، و61 ± 5 يوم، على التوالي للعينات F1 و F2. بالنسبة لعينة F1 ، أظهرت نتائج أسئلة CATA وجود فروق ذات دلالة إحصائية لكل من السمات السلبية (قديم/ عفن ، والطماطم الجافة ، الصلابة ، العجين الخام) والسمات الإيجابية (لينة، نكهة الفوكاشا النموذجية ، الطماطم الحلوة ، الطماطم الطازجة). أما بالنسبة لعينة F2 ، أظهرت نتائج أسئلة CATA وجود فروق ذات دلالة إحصائية فيما يتعلق بكل من السمات السلبية (قديم/عفن ، قاسي ، طعم البصل) وسمات إيجابية (طعم البصل الناعم). بالنسبة لكلا النوعين من العينات، لوحظ أيضًا أن العينات الطازجة كانت مثل تلك المخزنة لمدة 60 يومًا. أوضحت النتائج التي توصلنا إليها أنه لا يوجد ارتباط كبير بين درجات الإعجاب بالمتغيرات الاجتماعية والسكانية (العمر والجنس). نوصي بضرورة متابعة الدراسة الحالية مع عدد أكبر من المستهلكين. يجب أن تقيّم الدراسات المستقبلية السمات النفسية والشخصية للمشاركين.

ث