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Sensory descriptors of food texture

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Abstract

Sensory Science is essential in the food industry to develop or optimize a food product and to meet consumer's expectations (texture, taste, flavour, odor) and nutritional (e.g.: diet or allergy), functional (e.g.: dysphagia, Alzheimer) or age-related (e.g.: children or elderly) needs. For example, texture modified foods (including pureed and transitional foods *i.e. food that start with one texture and change into another because of moisture or heating*) are available for people with dysphagia. In a design process, characterization of texture is essential. Instrumental measurements or simple methods (with fork or spoon) proposed by the IDDSI initiative can be performed to characterize texture modified food but these methods are not always relevant for understanding consumer sensations. Sensory characterization can be used but sensory methods and texture properties are complex to evaluate. Sensory texture descriptors can be determined by different methods (by using a panel or individually) and these descriptors can be assessed in different ways. This review is useful for listing the sensory methods in general and, more precisely, sensory descriptors used to characterize the oral texture of cereal and pureed foods. We found that 48% of the reviewed publications used specific oral texture descriptors and that 14 descriptors could be identified as the most popular. These results should be considered to facilitate the choice of sensory texture descriptors in future studies on texture-modified foods. This review also demonstrates that it is difficult to find a consensus between studies using different evaluation methods for the same descriptor.

Keywords

Sensory texture, food texture, dysphagia, oral perception, transitional food, pureed

1. Introduction

In 2012, the International Dysphagia Diet Standardisation Initiative (IDDSI) was founded to develop standard international terminology and definitions to characterize texture modified foods (pureed and transitional foods including minced and moist, soft and bite sized, and easy to chew/regular foods) and thickened liquids (Cichero et al., 2017). This classification is essential to ensure that a product has an adequate and safe texture that meets the specific needs of each person with a swallowing disorder. IDDSI tests (flow or textural measurements) are quick and easy to perform and allow determination of the level of drink thickness and food texture (Su et al., 2018). For example, cohesiveness and adhesiveness of puree (level 4 of IDDSI) are determined by a spoon tilt test. The puree should maintain its shape on the spoon and fall easily when the spoon is tilted, indicating that the puree is cohesive but not adhesive or sticky (Cichero et al., 2017). Also, soft and bite-sized foods (1.5 x 1.5 cm pieces, level 6 of IDDSI) can be mashed by the fork pressure test (without return to the original form) and requires chewing before swallowing. However, this classification does not make it possible to differentiate the food products according to their sensory characteristics and their ease of being swallowed. Also, the hedonic appreciation of texture modified foods must also be considered to increase consumer satisfaction and pleasure. To improve this hedonic aspect, it is important to offer different food textures for the same level of dysphagia, which implies more precisely characterizing the texture of the products using, for example, sensory analyzes.

Sensory Science is very useful for food industry to meet consumer's expectations in terms of their visual, olfactory, touch sensation and taste preferences. Several studies used sensory analyses to demonstrated a hedonic appreciation (Basu & Shivhare, 2010; Campbell, Euston, & Ahmed, 2016; Kaur, Singh, & Kaur, 2017; Mau et al., 2020) or a specific sensory description (Bernklau et al., 2017; Bustos, Perez, & León, 2011; Cordelino et al., 2019; Oliveira de Souza et al., 2018; Park, Choi, & Kim, 2015; Pasqualone et al., 2019) of different food products. Sensory Science is always evolving to offer new concept such as sensory complexity (Palczak, Blumenthal, & Delarue, 2019) or more suitable methods such as the oral comfort analysis for elderly people (Vandenberghe-Descamps, Labouré, Septier, Feron, & Sulmont-Rossé, 2018). To characterize sensory aspects of food, the use of sensory descriptors is essential. These descriptors can be evaluated during observation (visual appearance and smell), touching (mostly texture) and tasting of the food (noise, texture, taste and flavor). The product must first be observed, then smelled, tasted (first bite), chewed and finally the aftertaste sensations (after swallowing) can be evaluated (Dijksterhuis et al., 2007). During tasting, the sensory descriptors can also be classified according to different tasting times: at the first bite, during chewing, during swallowing and after swallowing (aftertaste) (Dijksterhuis et al., 2007; Fiszman, Salgado, Orrego, & Ares, 2015; Giboreau et al., 2007; Szczesniak, 2002). Recently, Ong, Steele, & Duizer (2018) were interested in the sensory characteristics of thickened liquids and they demonstrated that differences in sensory properties are detected in a same IDDSI level depending on the product to be thickened and

the thickener used. These results confirm that it is essential to characterize sensory aspects especially for specific populations consuming texture modified foods and thickened liquids. The most important sensory aspect for the characterization of texture modified foods intended to dysphagia patients is obviously the texture to avoid, for example, choking (Atherton, Bellis-Smith, Cichero, & Suter, 2007). However, the few studies on sensory methods with dysphagia people have used hedonic methods instead possibly because they are easier to set up (Dahl et al., 2005; Nyström et al., 2015; Okkels et al., 2018; Stahlman et al., 2000). There is a real challenge to realize sensory characterization of product in addition of the IDDSI measurement. This approach will allow to propose to each dysphagic person a wide range of products with the right level of food texture.

As explained by Szczesniak (2002), texture is a multi-parameter attribute with a large gamut of characteristics that derive from the structure of the food and that can be detected by several senses. Sensory texture can be evaluate in different ways: manually (by spreading or touching) using descriptors such as powdery, rough or sticky surface, oily, elasticity, friability, etc. (Martínez, Santa Cruz, Hough, & Vega, 2002; Martinez, Ribotta, Leon, & Añón, 2007; Monnet, 2019) or during tasting using descriptors like crumbly, crunchy, dry, firm, lumpy, smooth, etc. (Dijksterhuis et al., 2007; Fiszman et al., 2015; Giboreau et al., 2007). Of course, the description is also dependent of the product. Moreover, according to the method used, the descriptor can be defined by the panel together (ex.: QDA, Flavor or Texture Profile) or individually (ex: Free-Choice profiling, Flash profile) (Lawless & Heymann, 2010; Liu, Bredie, Sherman, Harbertson, & Heymann, 2018). In order to simplify the use of sensory descriptors and standardize their definition and evaluation method for dysphagia problems it would be interesting to propose a universal glossary of sensory texture descriptors. For example, Pascua, Koç, & Foegeding (2013) reviewed the terminology, definition and evaluation methods used at different stages of the oral processing (non-oral, tongue-palate compression, first chew, mastication and residual) to evaluate the sensory texture of semisolids and solids food such as dairy products (yogurt, butter, cheese, etc.), dessert (pudding, custard) and proteins gels (meat or whey protein). They observed that terminology and definition of the sensory descriptors were often similar between studies, but that the oral evaluation methods were performed differently. Pascua et al. (2013) suggested that a reference language to describe the food texture need to be developed to facilitate the comparisons between studies. However, the wide variety of food products compared by Pascua et al. (2013) may have limited the possibility of finding a consensus between the oral evaluation methods. For specific populations such as people with dysphagia, there is an important need to define sensory descriptors to offer foods with appreciable and safe textures. Recently, van der Stelt, Mehring, Corbier, van Eijnatten, & Withers (2020) developed a mouthfeel wheel terminology for medical nutrition products to facilitate communication and development of these specific products. However, in this study, a trained sensory panel without dysphagia symptoms was used and the terminology developed must be validated by the specialists and the patients concerned by this medical nutrition. To our knwoledge, few studies propose

sensory methods using dysphagia patients to characterize modified texture foods (ex. pureed, thickened liquids) (Dahl, Whiting, Isaac, Weeks, & Arnold, 2005; Nyström, Qazi, Bülow, Ekberg, & Stading, 2015; Okkels et al., 2018; Stahlman, Garcia, Hakel, & Chambers IV, 2000).

In this review, we propose to focus on pureed (level 4 of IDDSI) and transitional foods (level 5 to 7 of IDDSI) and to exclude dairy products, meat and fish to limit the diversity of texture and taste. We will present an overview of the sensory methods and the specific sensory descriptors used to study the oral texture of pureed and transitional foods. Then, we will discuss the most used specific sensory texture descriptor and define the evaluation method of these descriptors. Finally, we will propose some recommendations to characterize texture modified foods for dysphagia patients using specific sensory texture descriptors.

2. Bibliographic study

This bibliographic study was realized between September and November 2019 using Science direct and PubMed databases. Different combinations of specific keywords were used: "food AND texture AND/OR sensory", "Sensory analysis" AND/OR profile AND/OR descriptors". To reduce the number of articles matching with these criteria (~ 40 000 documents), the bibliographic study was limited to articles published between 2000-2020 and to review and research articles (~ 32 000 articles). The selection of articles was then based on the presence of a sensory method (using a trained or not trained panel) with a textural aspect (~ 900 articles) of specific food products such as pureed and transitional foods (more specifically cereal products and excluding dairy product, meat and fish). To find these food products additional specific keywords were added: biscuit, cake, cookie, puree, cracker or pasta. Figure 1 shows the distribution of the 38 articles studied according to the type of food. The biscuit is the most represented product in this bibliographic research (11 references). Cake, bread, cookie, cracker, pasta and puree have been listed in 4 to 6 references. The category named "other" represents the products which were found in 2 references or less each (fried pastry, pancake, waffle and pizza).

3. Type of sensory descriptor to study the textural aspect of food

Despite the search of sensory texture descriptors, several articles using general descriptor and hedonic measures were found. Table 1 presents the repartition of the references according to the type of sensory descriptor used to evaluate food texture: general (ex.: texture) and specific descriptors (ex.: crunchy) and the sensory methods (hedonic or descriptive). In this review, 14% of the studied articles used general descriptors and all articles used it during a hedonic evaluation (Table 1). For example, Kaur et al. (2017) studied the effects of different levels of flaxseed flour on sensory appreciation of cookies. General descriptors such as color, flavour, texture and overall acceptability were used to evaluate

cookies with 9-point hedonic scale. This kind of evaluation allow to compare cookies between them but did not give specific information about a precise color, flavour or texture.

Specific sensory descriptor of texture implies use of specific terminology to characterise the texture of a product. These specific descriptors can be applied to manual texture (determine by touching or spreading) and to oral texture perception (determine by tasting, chewing and swallowing). In this review, specific descriptors of manual texture represent 11% of the total articles studied and were used to perform a descriptive analysis (Table 1). In contrast, for specific descriptors of the oral texture, 27% of articles used an hedonic evaluation and 48% of articles used a descriptive analysis (Table 1).

Few articles also used more than one type of descriptor. For example, Bustos et al. (2011) and Oliveira de Souza et al. (2018) used general descriptor to perform an hedonic evaluation and used specific descriptor during descriptive analysis. Others articles also combined the use of manual and oral specific descriptors to perform descriptive analysis (Martínez et al., 2002; Martinez et al., 2007; Monnet, 2019; Pasqualone et al., 2019).

As part of this review, we focused on specific sensory descriptors of oral texture, which are represented by 48% of the 38 articles reviewed. These 21 articles have been studied in more detail to define the sensory methods used to describe oral texture (Table 2). The table also presents the number of assessors and if they were trained or not. As describe by Lawless & Heymann (2010) a generic descriptive analysis requires between 8 and 12 assessors who have been trained to be sure that they understand and they are agree with the definition and evaluation method of the sensory descriptors. In this review, the number of assessors were generally between 6 and 15, but some other references used more assessors (Fiszman et al., 2015; Hama-ba et al., 2018; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018). In addition, assessors were not trained in 4 studies (Booth et al., 2003; Hama-ba et al., 2018; Martinez et al., 2007; Vandenberghe-Descamps et al., 2018).

4. Overview of the specific sensory descriptors of the oral texture

This bibliographic search allowed to find 60 specific sensory descriptors of the oral texture. Table 3 presents all the specific texture descriptors found and their corresponding references. Some descriptors were combined and considered as synonyms because their definition or their method of analysis were very similar. Six groups of synonymous descriptors were formed: “adhesiveness/sticky”, “doughy/pasty”, “fatty/greasy/oily”, “floury/mealy”, “grainy/gritty” and “soft/smooth” which resulted in 53 specific descriptors (or groups of synonyms) of the oral texture. The combination of adhesiveness and sticky was also proposed by Pascua et al. (2013), and is in agreement with Sharma et al. (2017) who define adhesiveness by the stickiness of the sample. However, Cordelino et al. (2019) used these 2 terms for different evaluation of pasta. They define adhesiveness by “the extent to which two strands

of pasta stick together when separated" and stickiness by "the extent to which strands of pasta stick to hands/mouth". For this article, we only considered the term stickiness because the definition of adhesiveness was more related to the interaction between pasta than the oral perception. The combination of the descriptors soft and smooth were in agreement with the panelist formed in the study of Fernández-Sestelo et al. (2013) who associated smooth and tender as synonymous of soft. The synonyms groups grainy and gritty as well as fatty, greasy and oily were also combined by Pascua et al. (2013) because of their similar definition and evaluation method between different references. Dijksterhuis et al. (2007) also define gritty as dry grainy which are in agreement with the combination of grainy and gritty. Finally, we decided to combine doughy and pasty as well as floury and mealy because it seem clear that these words have a very similar definition.

The large number of sensory descriptors that can describe oral perceptions of texture greatly complicates the understanding and use of these descriptors. In addition, it is obvious that this very wide vocabulary does not simplify the comparisons between the studies. In order to facilitate the choice of sensory texture descriptors and improve their understanding, we decided to deepen the study of the most used texture sensory descriptors for oral perception in the revised articles.

5. How to choose a specific sensory texture descriptor for oral perception of pureed and transitional food?

The most used texture sensory descriptors were determined from the Table 2 for the descriptors that have been found in 3 articles or more. Figure 2 represents the repartition of the food product studied for the 14 most used texture sensory descriptors. These results show that some descriptors could be used to describe a large number of product while other descriptors are really more specific. For example, "adhesiveness/sticky" is the more polyvalent descriptor (used for 8 different products: biscuit, bread, cake, cookie cracker, pasta, puree and fried pastry (other)). We can also observe that the descriptor "hard" was the more used in this bibliographic with 20 references. The descriptor "hard" was used to describe 6 different products but mostly used for biscuit (7 articles), bread (4 articles) and cake (4 articles). In contrast, floury/mealy was specific to biscuit and puree.

It is also interesting to notice that biscuit can be described by all these most used descriptors except by the descriptor "cohesiveness" (Figure 1). This could be related to the fact that this product is the most studied in this bibliographic research. However, the descriptors "crispy", "crunchy" and "hard" appear to be the most used to describe biscuit.

These results also allow to compare the use of descriptors such as "dry" and "moist" which are opposite terms. Figure 2 shows that biscuit, cake and bread can be defining by the both terms while fried pastry (other) seems specific to "dry" and cracker to "moist". Indeed, some articles used both terms (Fiszman

et al., 2015; Oliveira de Souza et al., 2018) while other, like Pasqualone et al. (2019), used one scale with these two terms (from moist to very dry).

These results can be useful to better target the descriptors according to the product studied (in this case for cereal or puree products). For example, sticky, cohesiveness, plummy, fibrous, floury and smooth could be used to describe puree while sticky, chewiness, firm and grainy could be more appropriated to describe pasta. Obviously, the synonyms of the groups mentioned could also be used.

6. How to evaluate the specific sensory texture descriptor?

Once the sensory descriptors have been chosen, the appropriate evaluation method must be determined. The different objectives of the studies reviewed (relationship between sensory and instrumental measurements, impact of the composition, study of the oral processing, etc.) could have influenced the choice of evaluation methods. However, as the purpose of this review is to lead to a common sensory glossary, this information was not considered.

Table 4 compare the evaluation methods used for the 14 most popular specific descriptors (or group of synonymous descriptors) between all articles reviewed. As mentioned in the review of Pascua et al. (2013), focusing mainly on dairy products and protein gels, this table shows that it is also difficult to reach a consensus between the evaluation methods of the various articles on cereal and puree foods. Several articles don't provide any evaluation method for the sensory texture descriptors used, which greatly limits the comparison of different studies (Booth et al., 2003; Hama-ba et al., 2018; Martins et al., 2017; Oliveira de Souza et al., 2018; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018). When none or only one method of evaluation was provided for a descriptor, it was impossible to determine if there is a consensus or not between the references. Out of the 14 most used descriptors, consensus could not be determined (NA) for 4 descriptors (crumbly, crunchy, floury/mealy and soft/smooth), no consensus (No) was found for 7 descriptors (adhesiveness/sticky, chewiness, crispy, dry, fatty/greasy/oily, hard and moist) and consensus (Yes) was found for only 3 descriptors (cohesiveness, firm and grainy/gritty) (Table 4).

Among the evaluation methods provided, we can observe major differences. For example, for the descriptor "chewiness", six out of 7 references provided a definition. Five articles agree to determine the chewability from the moment the food can be swallowed which is also in agreement with the sensory definition of chewiness proposed by Szczesniak, 2002. However, two articles used the number of chewing (Bernklau et al., 2017; Cordelino et al., 2019), two others used the length of time to masticate (Bustos et al., 2011; Martinez et al., 2007) and one the energy necessary to masticate (Park et al., 2015). Finally, an article considered the force required to drive molars through without referring to the time of swallowing (Dijksterhuis et al., 2007).

Other differences between references can be subtler like the evaluation methods for the descriptor "hard". For this descriptor, the 9 references out of 16 provided an evaluation method. These methods were mostly based on the bite force (chewing, compression or deformation force), but some references specify the use of front teeth (Park et al., 2015; Shin et al., 2013) or molars (Heenan et al., 2009; Martínez et al., 2002) which can lead to different perceptions. According to Szczesniak, 2002, it would be appropriate to use the compression force between molars teeth for the evaluation of solids food and the compression force between tongue and palate for semi-solids foods. The evaluation method therefore seems very important to clarify in order to understand the meaning of the descriptor and to be able to compare results between studies and products.

Another interesting example concerns the use of the fatty/greasy/oily descriptor. Half of articles using one of these descriptors did not provide an evaluation method, possibly because it seems very simple to evaluate whether a food is perceived to be fatty or not (Fiszman et al., 2015; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018). However, Heenan et al. (2009) used the descriptor "fat" with a very different method of evaluation defined as the degree of residual oiliness left on the oral cavity after swallowing the sample. This latter definition, however, seems to be much closer to the evaluation methods used to evaluate the descriptor "oily mouth coating". Ledeker et al. (2014) used "oily mouth coating" to describe the sensation of having a slick coating on the tongue and other mouth surfaces while Sharma et al. (2017) used it for an intensity of oily coating in the inner surface of mouth after the sample has been swallowed. These different evaluation methods can therefore lead to misunderstandings and limit comparisons between studies. In addition, even if the descriptor "oily mouth coating" has not been recognized among the most used descriptors, it is important to note that the various studies do not agree on the fact that it is a texture descriptor. Dijksterhuis et al. (2007) considers that this term is rather an after feel descriptor, defined as a layer of fat in the mouth and on the tongue" than a texture descriptor. In the same order of ideas, Dijksterhuis et al. (2007) used crunchy as a sound descriptor during chewing, defined as a high pitched sound, light sound, longer sounding comparatively to snapping, instead of a texture descriptor.

The evaluation method of the sensory descriptor crispy also seem to be difficult to define. Table 4 shows that half of references didn't provided any evaluation methods and there was no consensus between the 3 evaluation methods found. These observations are in agreement with those of Roudaut, Dacremont, Vallès Pàmies, Colas, & Le Meste (2002). In their review, they explained that the evaluation of the descriptor "crispy" was realized with a magnitude estimation method (ratio scales, large number of untrained assessors) at the beginning and has evolved into a descriptive analysis (interval scales, small number of trained assessors) in the 1980's. This change in sensory method therefore led to the appearance of a more precise definitions and methods to evaluate the sample. Roudaut et al. (2002) observed a large diversity of meaning between the reviewed articles. They found five different aspects in the definition (structure, noise, force, fracture and particle) and three methods of evaluation (crush

with molars, incisors or fingers). In our review, we found three different aspects (energy, noise and force) and 2 evaluation methods (force with unspecified teeth or with molar teeth) (Table 4).

7. Recommendations to characterize texture modified foods for dysphagia patients using specific sensory texture descriptors

Among the most used sensory descriptors to evaluate pureed and transitional food and in a context of texture characterization for people with dysphagia, we recommend using the following descriptors as a priority: adhesivness/sticky, chewiness, cohesiveness, grainy/gritty, moist and soft/smooth. As explain by Vandenberghe-Descamps et al. (2018) oral comfort during eating of people with dysphagia depends on chewiness, easiness to humidify and to swallow as well as the softness of the food. Ross, Tyler, Borgognone, & Eriksen, (2019) demonstrated, using thickened fluid, that oral cohesiveness (how well the bolus holds together on the tongue) and stickness (stickiness of the sample when depressed between the tongue and roof of mouth and then swallowed) were relevant for common swallowing disorders. Also, adhesiveness and graininess have already been shown to be useful for sensory evaluation of thickened liquids by Ong et al., (2018). Sensory analyzes with panel of dysphagia people using these specific texture descriptors would be useful to complete the information obtained by the testing methods of the IDDSI and thus allow to differentiate more precisely the food products for specific populations. Nyström et al.(2015) demonstrated that a panel of dysphagia people perceived a large difference in swallowing between three fluids while a healthy panel didn't perceived difference possibly due to their normal and involuntary swallowing. This demonstrates the importance of better understanding the sensory perceptions of specific populations. Obviously, as describe by Methven, Jiménez-Pranteda, & Lawlor(2016), some limitations must be taken into account due to the age and health of patients (fatigue, confusion, medication). The use of specific descriptor, simple and rapid evaluation method as well as the assistance of medical personnel could improve the implementation of sensory analysis with a panel of dysphagia people.

8. Conclusions

This review shows how complex it is to find a common glossary. It seems even more difficult to find a consensus about the sensory evaluation method, especially since several studies don't provide this information. The evaluation method of specific sensory descriptor must therefore be clear and precise for each sensory descriptor in order to obtain a fair and repeatable analysis between panelists and between studies. This review also highlight that certain descriptors are more popular (hard, crispy, crunchy, etc.) than others (brittle, crackling, elastic, etc.) to describe pureed and transitional foods. Also, a list of useful sensory descriptors to characterize texture modified foods for dysphagia patients was proposed to supplement the instrumental measurements used by the IDDSI methods. Additional bibliographic studies would be essential to widen the range of food products studied (ex.: dairy, meat,

vegetable products) and the choice of the evaluation method of the sensory descriptors will have to be in adequacy with the needs of specific populations such as people with dysphagia.

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Ethical statements

The authors declare that they do not have any conflicts of interest. This study does not involve any human or animal testing.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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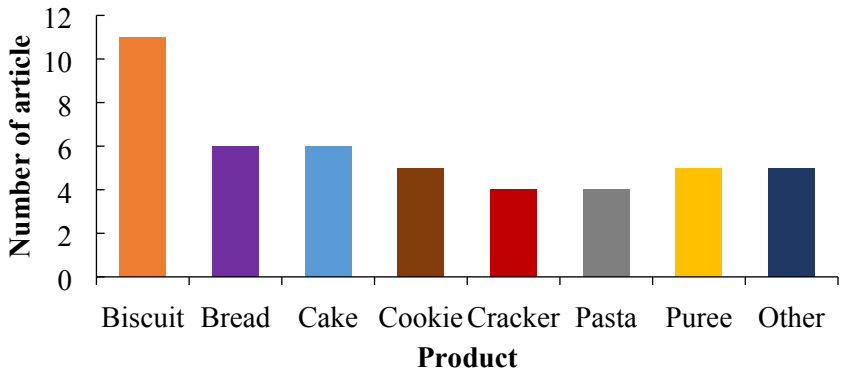

Figure 1. Repartition of articles according to the type of food studied.

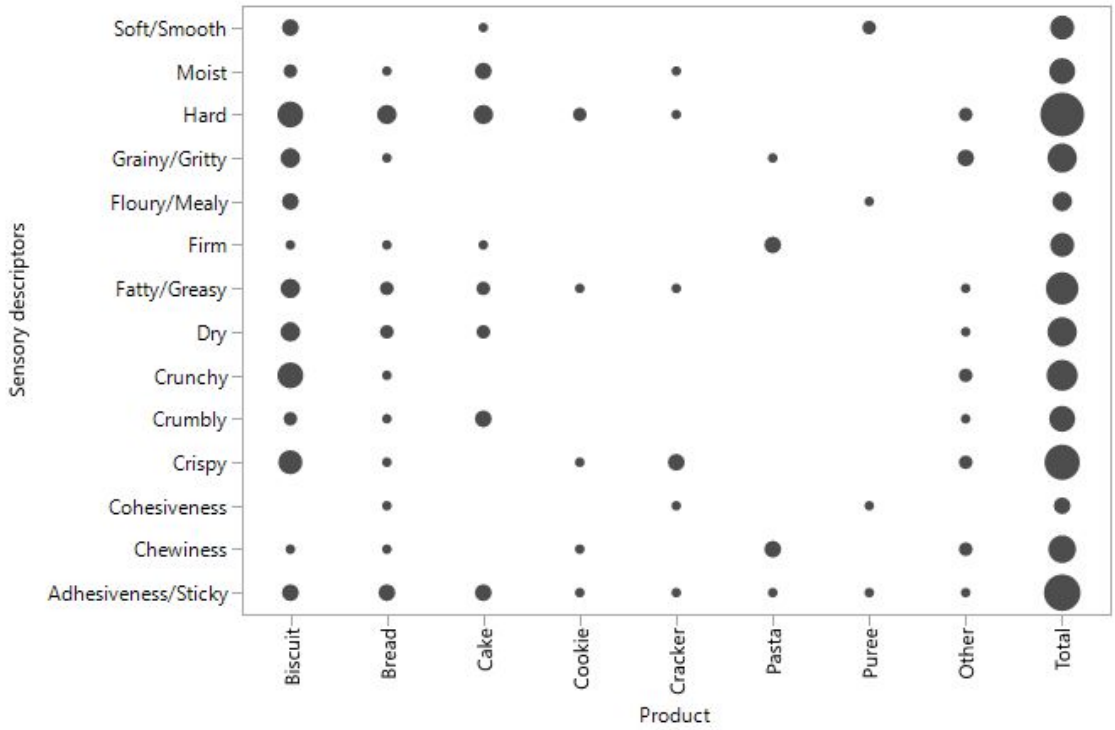

Figure 2. Representation of the most used sensory descriptors of texture and their distribution according to the studied products. "Other" represent pizza crust and/or fried pastry.

Table 1

Repartition of the references for each type of sensory descriptor.

Type of sensory texture descriptor	Reference	Repartition
General descriptor of sensory texture		
Oral texture (*hedonic)*	Duong, Balaban, Perera, & Bi, 2015; Kaur et al., 2017; Mau et al., 2020; Oliveira de Souza et al., 2018; Selvakumaran et al., 2019; Sert, Demir, & Ertaş, 2015	14 %
Specific sensory descriptor of texture		
Manual texture (descriptive)	Bustos et al., 2011; Martínez et al., 2002; Martinez et al., 2007; Monnet, 2019; Pasqualone et al., 2019	11 %
Oral texture (hedonic)	Adeola & Ohizua, 2018; Akonor et al., 2017; Fernández-Sestelo et al., 2013; Hafez, 2012; Komolka et al., 2016; Olivera & Salvadori, 2009; Omobuwajo, 2003; Pages, Bertrand, Ali, Husson, & Lê, 2007; Venkatachalam & Nagarajan, 2017; Volpini-Rapina, Sokei, & Conti-Silva, 2012; Zolfaghari, Mohebbi, & Najariyan, 2014	27 %
Oral texture (descriptive)	Bernklau et al., 2017; Booth, Earl, & Mobini, 2003; Bustos et al., 2011; Cordelino et al., 2019; Dijksterhuis et al., 2007; Fiszman et al., 2015; Hama-ba, Ouattara, Savadogo, Simpore, & Diawara, 2018; Heenan, Hamid, Dufour, Harvey, & Delahunty, 2009; Ledeker, Suwonsichon, Chambers, & Adhikari, 2014; Martínez et al., 2002; Martinez et al., 2007; Martins, Pinho, & Ferreira, 2017; Monnet, 2019; Oliveira de Souza et al., 2018; Park et al., 2015; Pasqualone et al., 2019; Sakač et al., 2015; Sharma, Kristo, Corredig, & Duizer, 2017; Shin, Kim, & Kim, 2013; Tarancón, Fiszman, Salvador, & Tárrega, 2013; Vandenberghe-Descamps et al., 2018	48 %

Table 2
Sensory methods used to describe oral texture

Reference	Year	Sensory methods	Number of assessors	Have the assessors been trained ?
Martínez et al.	2002	QDA	10	Yes
Booth et al.	2003	Similarity to the standard	6	No
Dijksterhuis et al.	2007	Descriptive sensory profiling panel	8	Yes
Martinez et al.	2007	Generic descriptive analysis	13	No
Heenan et al.	2009	QDA	11	Yes
Bustos et al.	2011	Multiple comparative method	9	Yes
Tarancón et al.	2013	Free choice profile	28	Yes
Shin et al.	2013	QDA with the modification of using product-specific references	8	Yes
Ledeker et al.	2014	Hybrid method adapted from the flavor profile method	7	Yes
Sakač et al.	2015	Descriptive analysis	8	Yes
Park et al.	2015	QDA	8	Yes
Fiszman et al.	2015	Vocabulary generation: Repertory grid, comparison of the whole sample set, individual sample description	90	NA
Martins et al.	2017	Descriptive analysis	13	Yes
Sharma et al.	2017	Partial Napping and descriptive analysis	9	Yes
Bernklau et al.	2017	QDA	10	Yes
Oliveira de Souza et al.	2018	CATA test	15	NA
Vandenberghe-Descamps et al.	2018	Food comfortability questionnaire	42	No
Hama-ba et al.	2018	Profile test	30	No
Cordelino et al.	2019	QDA	9	Yes
Monnet	2019	QDA	11	Yes
Pasqualone et al.	2019	QDA	8	Yes

Table 3
List of specific sensory descriptors of the oral texture.

Descriptors	References
Adhesiveness/Sticky	Cordelino et al., 2019; Dijksterhuis et al., 2007; Fiszman et al., 2015; Heenan et al., 2009; Martínez et al., 2002; Sakač et al., 2015; Sharma et al., 2017; Vandenberghe-Descamps et al., 2018
Astringency	Pasqualone et al., 2019
Bite force	Bernklau et al., 2017; Dijksterhuis et al., 2007
Bolus formation	Dijksterhuis et al., 2007; Martínez et al., 2002
Brittle	Dijksterhuis et al., 2007; Tarancón et al., 2013
Chalky	Ledeker, Suwonsichon, Chambers, & Adhikari, 2014
Chewiness	Bernklau et al., 2017; Bustos et al., 2011; Cordelino et al., 2019; Dijksterhuis et al., 2007; Martinez et al., 2007; Park et al., 2015; Tarancón et al., 2013
Coarse	Heenan, Hamid, Dufour, Harvey, & Delahunty, 2009
Cohesiveness	Martínez et al., 2002; Martins et al., 2017; Sharma et al., 2017
Compact	Fiszman et al., 2015; Oliveira de Souza et al., 2018
Contrast inside-outside	Dijksterhuis et al., 2007
Crackling	Dijksterhuis et al., 2007
Crispy	Bernklau et al., 2017; Booth et al., 2003; Dijksterhuis et al., 2007; Martínez et al., 2002; Park et al., 2015; Tarancón et al., 2013
Crumbly	Dijksterhuis et al., 2007; Fiszman et al., 2015; Oliveira de Souza et al., 2018
Crunchy	Booth et al., 2003; Fiszman et al., 2015; Heenan et al., 2009; Martins et al., 2017; Tarancón et al., 2013
Disintegrates	Dijksterhuis et al., 2007
Doughy/Pasty	Fiszman et al., 2015; Vandenberghe-Descamps et al., 2018
Dry	Dijksterhuis et al., 2007; Fiszman et al., 2015; Oliveira de Souza et al., 2018; Pasqualone et al., 2019; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018
Duration of chewing	Dijksterhuis et al., 2007
Elastic	Cordelino et al., 2019
Even	Fiszman et al., 2015
Fatty/Greasy/Oily	Fiszman et al., 2015; Heenan et al., 2009; Martínez et al., 2002; Sakač et al., 2015; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018
Fibrous	Fiszman et al., 2015; Ledeker et al., 2014
Firm	Bustos et al., 2011; Cordelino et al., 2019; Martinez et al., 2007; Vandenberghe-Descamps et al., 2018
Floury/Mealy	Fiszman et al., 2015; Ledeker et al., 2014; Tarancón et al., 2013
Fluffy	Oliveira de Souza et al., 2018
Fracturability	(Sakač et al., 2015)
Gooey	Dijksterhuis et al., 2007
Grainy/Gritty	Cordelino et al., 2019; Dijksterhuis et al., 2007; Fiszman et al., 2015; Pasqualone et al., 2019
Groats	Komolka et al., 2016
Hard	Booth et al., 2003; Dijksterhuis et al., 2007; Fiszman et al., 2015; Hama-ba et al., 2018; Heenan et al., 2009; Martínez et al., 2002; Oliveira de Souza et al., 2018; Park et al., 2015; Sakač et al., 2015; Shin et al., 2013; Tarancón et al., 2013; Vandenberghe-Descamps et al., 2018
Heavy	Fiszman et al., 2015
Homogenous	Fiszman et al., 2015
Light	Fiszman et al., 2015
Lumpy	Fiszman et al., 2015
Melting	Dijksterhuis et al., 2007; Vandenberghe-Descamps et al., 2018
Moist	Fiszman et al., 2015; Heenan et al., 2009; Martínez et al., 2002; Oliveira de Souza et al., 2018
Noise	Martínez et al., 2002
Oily mouth coating	Ledeker et al., 2014; Sharma et al., 2017
Particule size or shape	Sakač et al., 2015
Porosity	Fiszman et al., 2015
Pulpy residue	Ledeker et al., 2014
Rough	Fiszman et al., 2015
Sandy	Dijksterhuis et al., 2007; Fiszman et al., 2015
Slick	Ledeker et al., 2014
Slimy	Ledeker et al., 2014
Soft/Smooth	Fiszman et al., 2015; Hama-ba et al., 2018; Oliveira de Souza et al., 2018; Sharma et al., 2017
Splinters	Dijksterhuis et al., 2007
Spongy	Fiszman et al., 2015
Springy	Dijksterhuis et al., 2007
Stringy	Vandenberghe-Descamps et al., 2018
Tough	Dijksterhuis et al., 2007
Viscosity	Ledeker et al., 2014

Table 4

Evaluation method of the most used texture descriptors and determination of consensus between the different references.

Descriptor	Reference	Products	Evaluation method	Consensus
Adhesiveness/Sticky	Cordelino et al., 2019	Pasta	The extent to which strands of pasta stick to hands/mouth.	No
	Dijksterhuis et al., 2007	Fried pastry, bread	Sticks to molars and palate.	
	Fiszman et al., 2015	Biscuit	NA	
	Heenan et al., 2009	Biscuit, bread, cake	Force required to remove sample completely from the palate, using the tongue during consumption.	
	Martínez et al., 2002	Cracker	After 8–10 bites measure the quantity of product stuck to the teeth.	
	Sakač et al., 2015	Cookie	The force required to remove cookie that adheres to the mouth or to a substrate.	
	Sharma et al., 2017	Puree	Stickiness of the sample.	
	Vandenberghe-Descamps et al., 2018	Bread, cake	NA	
Chewiness	Bernklau et al., 2017	Pizza crust	The degree to which a sample takes a number of chews until the product is ready for swallowing.	No
	Bustos et al., 2011	Pasta	The length of time required to masticate the spaghetti to a state of swallowing.	
	Cordelino et al., 2019	Pasta	The number or chews required to reduce the sample to a state ready for swallowing.	
	Dijksterhuis et al., 2007	Fried pastry, bread	Force required to drive molars through.	
	Martinez et al., 2007	Pasta	The length of time required to masticate the spaghetti to a state of swallowing.	
	Park et al., 2015	Cookie	The energy necessary to masticate solid foods so that they can be easily swallowed.	
	Tarancón et al., 2013	Biscuit	NA	
Cohesiveness	Martínez et al., 2002	Cracker	After 8–10 bites measure the degree with which the resulting mass keeps together.	**Yes**
	Martins et al., 2017	Bread	NA	
	Sharma et al., 2017	Puree	Degree to which the mass of food and saliva hold together after mastication and while swallowing.	
Crispy	Bernklau et al., 2017	Pizza crust	NA	No
	Booth et al., 2003	Biscuit	NA	
	Dijksterhuis et al., 2007	Fried pastry, bread	Cracks, you can force your teeth through slowly, airier than crackling. Associate with fresh disintegrates into pieces smaller than with crackling.	
	Martínez et al., 2002	Cracker	Energy with which the cracker goes crack-crunch-bang during the first 2–3 bites with molar teeth.	
	Park et al., 2015	Cookie	The force and noise with which a sample breaks when chewed with molar teeth.	
	Tarancón et al., 2013	Biscuit	NA	
Crumbly	Dijksterhuis et al., 2007	Fried pastry, bread	Small pieces in the mouth.	NA
	Fiszman et al., 2015	Biscuit	NA	
	Hafez, 2012	Cake	NA	
	Oliveira de Souza et al., 2018	Cake	NA	
Crunchy	Booth et al., 2003	Biscuit	NA	NA
	Fiszman et al., 2015	Biscuit	NA	
	Heenan et al., 2009	Biscuit	Degree of brittleness when force is applied between the molars.	
	Martins et al., 2017	Bread	NA	
	Tarancón et al., 201	Biscuit	NA	
Dry	Dijksterhuis et al., 2007	Fried pastry, bread	Saliva absorbing during chewing.	No
	Fiszman et al., 2015	Biscuit	NA	
	Oliveira de Souza et al., 2018	Cake	NA	
	Pasqualone et al., 2019	Biscuit	Dryness perceived at the surface of biscuit.	
	Tarancón et al., 2013	Biscuit	NA	
	Vandenberghe-Descamps et al., 2018	Bread, cake	NA	

Table 4 (*continued*)

Descriptor	Reference	Products	Evaluation method	Consensus
Fatty/Greasy/Oily	Fiszman et al., 2015	Biscuit	NA	
	Heenan et al., 2009	Biscuit, bread, cake	Degree of residual oiliness left on the oral cavity after swallowing the sample.	
	Martínez et al., 2002	Cracker	Degree of greasiness perceived during mastication.	
	Sakač et al., 2015	Cookie	Surface textural attributes relating to the perception of the quantity or quality of fat in a cookie.	No
	Tarancón et al., 2013	Biscuit	NA	
	Vandenberghe-Descamps et al., 2018	Bread, cake	NA	
Firm	Bustos et al., 2011	Pasta	The force required to cut through the spaghetti using the front teeth.	
	Cordelino et al., 2019	Pasta	Force required to bite completely through the sample.	**Yes**
	Martinez et al., 2007	Pasta	The force required to cut through the spaghetti using the front teeth.	
	Vandenberghe-Descamps et al., 2018	Bread, cake	NA	
Floury/Mealy	Fiszman et al., 2015	Biscuit	NA	
	Ledeker et al., 2014	Puree	The perception of fine, soft particles distributed within the product.	NA
	Tarancón et al., 2013	Biscuit	NA	
Grainy/Gritty	Cordelino et al., 2019	Pasta	Contains particulates upon biting/chewing.	
	Dijksterhuis et al., 2007	Fried pastry, bread	Dry grainy.	**Yes**
	Fiszman et al., 2015	Biscuit	NA	
	Pasqualone et al., 2019	Biscuit	Graininess perceived at the end of chewing.	
Hard	Adeola & Ohizua, 2018	Biscuit	NA	
	Booth et al., 2003	Biscuit	Difficult to bite off a piece.	
	Dijksterhuis et al., 2007	Fried pastry, bread	Resistance, with sound, snaps. Chewing force needed.	
	Fiszman et al., 2015	Biscuit	Difficult to bite.	
	Hama-ba et al., 2018	Biscuit	NA	
	Heenan et al., 2009	Biscuit, bread, cake	Force required to bite completely through sample placed between the molars.	
	Komolka et al., 2016	Biscuit	NA	
	Martínez et al., 2002	Cracker	By steadily compressing the cracker between the molars measure the force required for compression.	No
	Oliveira de Souza et al., 2018	Cake	NA	
	Park et al., 2015	Cookie	The force needed to bite through the cookie sample using the front teeth.	
	Sakač et al., 2015	Cookie	The force required to achieve a given deformation or penetration of a cookie.	
	Shin et al., 2013	Bread	The force needed to bite through the sample with the front teeth.	
	Tarancón et al., 2013	Biscuit	NA	
	Vandenberghe-Descamps et al., 2018	Bread, cake	NA	
	Volpini-Rapina et al., 2012	Cake	Minimum force necessary to compress the sample between the teeth.	
	Zolfaghari et al., 2014	Fried pastry	NA	
Moist	Fiszman et al., 2015	Biscuit	NA	
	Heenan et al., 2009	Biscuit, bread, cake	Amount of moisture perceived on the surface of the product, when in contact with the oral cavity.	No
	Martínez et al., 2002	Cracker	Measure the amount of saliva absorbed by the sample after 8–10 bites.	
	Oliveira de Souza et al., 2018	Cake	NA	
	Volpini-Rapina et al., 2012	Cake	Sensation caused by the amount of water presented in the cake.	
Soft/Smooth	Hama-ba et al., 2018	Biscuit	NA	
	Fernández-Sestelo et al., 2013	Puree	NA	
	Fiszman et al., 2015	Biscuit	NA	NA
	Oliveira de Souza et al., 2018	Cake	NA	
	Pages et al., 2007	Biscuit	NA	
	Sharma et al., 2017	Puree	Velvety feeling of the sample in the mouth.	

NA: Not applicable (evaluation method of the texture descriptor was not stated in the reference)