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Review Article

Texture Profile and Design of Food Product

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Abstract

Texture refers to surface characteristics and appearance of an object given by the size, shape, and density as well properties of a food that sensed by touch in the mouth and with the hands. We use many words to describe food texture foods can be soft or hard, mushy or crunchy, or smooth or lumpy. Texture is important to the enjoyment and acceptability of foods. Texture profile analysis is the measurement and description of the textural properties of food. Texture Profile Analysis is a popular double compression test for determining the textural properties of foods. The textural identity of any food is rarely a simple matter of understanding a singular attribute such as hardness or cohesiveness. The texture of any food is multi-faceted and tied to consumers' sensory expectations. It is not sufficient to deliver a food with a target hardness and springiness value if consumers do not like it and it does not meet their expectations for that food type. Depending on the textural attributes sought after by our clients we occasionally recommend capturing either chewiness or gumminess. Adhesiveness is a popular TPA parameter for deferent foods. An important factor in consumers' acceptability, beyond visual appearance and taste, is food texture. The elderly and people with dysphagia are more likely to present malnourishment due to visually and texturally unappealing food. Texture of food materials plays a key role in consumer acceptance and market value. Texture features are considered important from both quality assurance and food safety perspectives. Therefore, through customer feedback and extensive testing Texture Technologies has narrowed its recommended primary TPA characteristics to include hardness, cohesiveness, springiness, and resilience.

Keywords: Texture, Texture Profile, Sensory Organs

1. Introduction

1.1 Background

Texture refers to surface characteristics and appearance of an object given by the size, shape, and density. It is those properties of a food that are sensed by touch in the mouth and with the hands. We use many words to describe food texture foods can be soft or hard, mushy or crunchy, or smooth or lumpy. Texture is important to the enjoyment and acceptability of foods. Food texture has been defined by the International Standards Organization (ISO) in their standard vocabulary for sensory analysis as 'All the rheological and structure (geometrical and surface) attributes of a food product perceptible by means of mechanical, tactile, and where appropriate, visual and auditory receptors' (ISO, 2008). Texture of food materials plays a key role in consumer acceptance and market value. Texture features are considered important from both quality assurance and food safety perspectives .Texture is a key quality parameter used in the fresh and processed food industry to assess consumer acceptability. Among the texture characteristics, hardness (firmness) is one of the most important parameters, which is often used to determine the freshness of food. Springiness, cohesiveness, adhesiveness and gumminess are significant properties for the texture evaluation for meat-based products. Textural quality attributes of food may be evaluated by descriptive sensory or instrumental analyses. Although flavor is commonly found to be an important sensory factor responsible for the preference of foods, texture is often cited by consumers as the reason for not liking certain foods [1].

Texture profile analysis is the measurement and description of the textural properties of food. Texture Profile Analysis is a popular double compression test for determining the textural properties of foods. It is occasionally used in industries Texture profile analysis is another common method used to evaluate the texture of various food items, with one advantage to assess multiple variables at one time measurement. Texture of food like meat, variables include hardness, cohesiveness, springiness and chewiness. An important factor in consumers' acceptability, beyond visual appearance and taste, is food texture.

The textural identity of any food is rarely a simple matter of understanding a singular attribute such as hardness or cohesiveness. The texture of any food is multi-faceted and tied to consumers' sensory expectations. It is not sufficient to deliver a food with a target hardness and springiness value if consumers do not like it and it does not meet their expectations for that food type. Through customer feedback and extensive testing Texture Technologies has narrowed its recommended primary TPA characteristics to include hardness, cohesiveness, springiness, and resilience. Depending on the textural attributes sought after by our clients we occasionally recommend capturing either chewiness or gumminess.

Adhesiveness is a popular TPA parameter for deferent foods. An important factor in consumers' acceptability, beyond visual appearance and taste, is food texture. The elderly and people with dysphagia are more likely to present malnourishment due to visually and texturally unappealing food. Parameters observed in the texture profile analysis, hardness, adhesiveness and cohesiveness have been widely used for comparison of the sensory attributes and rheological properties of various foods Food texture plays an important role in whether the consumers like the food product or not . Texture is one of the attributes used by consumers to assess the food quality. Food texture is part of our sense when we feel the food in our month. It is can be described in the terms such as 'hard,' 'soft,' 'liquid,' 'solid,' 'rough,' 'smooth,' 'creamy,' 'crumbly,' 'crispy,' 'lumpy,' 'gritty,' etc. Such textural terms are directly related to the density, viscosity, surface tension, and other physical properties of a particular food product [2]. Ultimately, the textural characteristics of a food are measured by sensory assessment tests. Since texture is inextricably linked to food structures at micro- and macrolevels and are strongly influenced by the interactions of food biopolymers such as proteins, polysaccharides, and lipids, instrumental methods designed to measure rheological and/or mechanical properties may be used to establish parameters that relate to relevant sensory textural characteristics [3]. In addition to the direct contribution to consumer acceptance, texture also has a vital secondary role on modulating flavor release and perception. If flavor components in a food are to be sensed, they must be released from the food matrix to reach the appropriate taste receptors. This release of flavor is closely associated with the way in which the food structure breaks down in the mouth relating to both the initial texture of the food and the change in texture throughout mastication [4].

The objective of this study is to review design texture profile of different food products.

2. Literature Review

2.1 Texture Profile Analysis

Texture Profile Analysis is a popular double compression test for determining the textural properties of foods. It is occasionally used in other industries, such as pharmaceuticals, gels, and personal care. During a TPA test samples are compressed twice using a texture analyzer to provide insight into how samples behave when chewed. The TPA test was often called the "two bite test" because the texture analyzer mimics the mouth's biting action. The textural identity of any food is rarely a simple matter of understanding a singular attribute such as hardness or cohesiveness. The texture of any food is multi-faceted and tied to consumers' sensory expectations. It is not sufficient to deliver a food with a target hardness and springiness value if consumers do not like it and it does not meet their expectations for that food type. The beauty of TPA as an analytical method is that it can quantify multiple textural parameters in just one experiment. That is also the method's curse since many researchers rely on TPA's labeled characteristics without considering whether the test method provides metrics that are relevant to the experimental objective. TPA parameters have evolved since the test's creation. Through customer feedback and extensive testing Texture Technologies has narrowed its recommended primary TPA characteristics to include hardness, cohesiveness, springiness, and resilience. Depending on the textural attributes sought after by our clients we occasionally recommend capturing either chewiness or gumminess. Adhesiveness is a popular TPA parameter; however, a TPA test technique is not always the optimal method for quantifying adhesiveness, so TPA Adhesiveness should be adopted only after careful review of its suitability as an appropriate metric.

As the use of TPA evolved, so did its terms. Elasticity evolved into 'springiness' since elasticity already had rheological and engineering definitions. Brittleness evolved to 'factorability', which was perceived to be a more accurate description of the type of breakage that the metric measured.

The General Foods Texturometer had a similar vertical motion as universal testing instruments currently have, but it also had an eccentric cam which generated a sinusoidal movement that allowed it to stress products in a fashion that was more imitative of jaws chewing. Due to its pivot point the initial contact with the product was less parallel with the base than it was at the bottom of the stroke. The instrument's transducer experienced a significant amount of deflection which needed to be accounted for when more fundamental tests were conducted. The deflection was so great that strain data could not be reliably presented from tests generated with the instrument.

Figure 1: Test Texture of the Foods

2.2 Design for Textures Food

While a definitive meaning for texture is still not unanimous, the consensus seems to be, as defined by the International Organization for Standardization that texture comprises "all the mechanical, geometrical and surface attributes of a product perceptible by means of mechanical, tactile and, where appropriate, visual and auditory receptors [5] . In other words, texture seems to encompass every aspect of the food product that can be perceived by the human senses, particularly by the hands and mouth. Both texture perception and preference in humans vary greatly from person to person and are heavily influenced by an individual's personal experiences and culture. An important factor in consumers' acceptability, beyond visual appearance and taste, is food texture

In susceptible populations, such as the elderly and people with dysphagia, food texture is of utmost importance due to the risk of aspiration and choking [6,7]. Food textural properties are determinant on consumer acceptance and are often used to predict consumer's preferences and evaluate the foods' quality [8]. Food texture has been defined by the International Standards Organization (ISO) in their standard vocabulary for sensory analysis as 'All the rheological and structure (geometrical and surface) attributes of a food product perceptible by means of mechanical, tactile, and where appropriate, visual and auditory receptors' (ISO, 2008). Texture of food materials plays a key role in consumer acceptance and market value. Texture features are considered important from both quality assurance and food safety perspectives. Smith (1947) listed nine specific parameters contributing to overall food quality, of which five are linked to the concept of food texture . Texture is a key quality parameter used in the fresh and processed food industry to assess consumer acceptability. Among the texture characteristics, hardness (firmness) is one of the most important parameters, which is often used to determine the freshness of food. Springiness, cohesiveness, adhesiveness and gumminess are significant properties for the texture evaluation for meat-based products. Textural quality attributes of food may be evaluated by descriptive sensory or instrumental analyses [3].

Although flavor is commonly found to be an important sensory factor responsible for the preference of foods, texture is often cited by consumers as the reason for not liking certain foods [1]. The desired microbial food safety can be achieved over a wide range of temperature–time combinations. However, thermal processing also results in changes in physical, chemical and various organoleptic properties of foods , including texture. Apart from food preservation applications, thermal processing of food is employed to modify food texture of various food products. Increasing consumer demand for 'fresh-like' processed plant-based foods has resulted in research being carried out on methods to improve the texture of thermally processed products.

2.3 Principles of Solid Food Texture Analysis

Food texture is a major factor in the sensory evaluation of food quality, and it is critical or important in the quality grading and marketing of solid food. Tenderness is an important textural attribute in determining the quality, and hence the price, of meat and meat products. It is important that food producers and processors provide consistent, high-quality food with desirable food textural characteristics to the market. Food texture is a term that is difficult to define because it is the human's aggregate perception of a food item when it is acted upon by force or deformation in a complex form to cause changes or breakdown in the structure of the food. Bourne (2002) stated that the textural properties of a food are that group of physical characteristics that arise from the structural element of the food, are sensed primarily by the feeling of touch, are related to the deformation, disintegration, and flow of the food under a force, and are measured objectively by functions of mass, time, and distance. The difficulty in defining food texture also arises from the fact that there are a large variety of foods with vastly different textural characteristics and different people may have different descriptions or expectations for different types of food. Consequently, diverse terminologies have been used to describe the textural characteristics and it is hence important that objective, standard methods be adopted for measuring the textural properties of food.

2.4 Importance of Textures

Food texture plays an important role in whether the consumers like the food product or not . Texture is one of the attributes used by consumers to assess the food quality. Food texture is part of our sense when we feel the food in our month. It is can be described in the terms such as 'hard,' 'soft,' 'liquid,' 'solid,' 'rough,' 'smooth,' 'creamy,' 'crumbly,' 'crispy,' 'lumpy,' 'gritty,' etc. Such textural terms are directly related to the density, viscosity, surface tension, and other physical properties of a particular food product [9].The textural characteristics of a food are measured by sensory assessment tests.

2.5 Properties of Food and Principles of Processing

The texture of foods is mostly determined by their moisture and fat contents, and the types and amounts of structural carbohydrates (cellulose, starches and pectic materials), hydrocolloids and proteins that are present. Dar and Light (2014) describe methods to design and optimize textural characteristics and methods to assess texture. The journal 'Food Structure' reports research into food structure in the context of its relationship with molecular composition, processing and macroscopic properties (e.g. shelf stability, sensory properties) and can be found at www.journals.elsevier.com/food-structure.Food texture has a substantial influence on consumers' perception of 'quality' and during chewing, information on changes in the texture of a food is transmitted to the brain from sensors in the mouth, from the sense of hearing and from memory, to build up an image of the textural properties of the food.

2.6 Food Texture Design and Optimization

Food texture has been one of the fundamental characteristics that consumers look for in their food products and drives consumer liking and purchase intent. This has always been important but as science and technology have developed, it is increasingly possible to optimize texture and to target new product texture by design. There are three main categories of texture related product development initiatives that are commonly encountered in the food industry.

A) Developing a new food product with a desired target for texture as part of the overall eating experience.
B) Building back the texture of an existing food product after changing some key ingredients, for example, reducing fat in a sauce/dressing or adding whole grains to a bread loaf. In either case, it is desirable to maintain texture and the eating experience while creating a more healthy and desirable nutritional profile.
C) Transforming the texture of an existing product to one that is more highly desirable for the target consumers. One of the best ways to assess the attention on food texture is to look for texture claims on food products introduced to the marketplace. It is possible to do this using many different approaches.

In recent years, front of package texture claims have risen so that almost 1 in 2 products launched has a front of package texture claim. It is possible to review these claims through using any suitable market insight tool. A key area of focus where texture will need to be addressed is cost optimization and affordability initiatives as fluctuations in price of food.
Ingredients necessitate initiatives to optimize the cost of food formulations while maintaining a desirable eating experience. This could include replacement of costly sources of carbohydrates, fats or proteins with more cost-effective ones while minimizing undesirable changes in the eating experience. Another area of focus continues to be the reduction of ingredients that could be harmful if consumed in excess. Current initiatives in different parts of the world include reduction of different types of fats, salt, and sugar. These ingredients have an impact on texture and flavor but can also have impact on other factors including shelf stability and food safety. The impact of reducing or eliminating the undesirable ingredients from the food formulations needs to be compensated for by using a combination of ingredients and processing.

2.7 Texture Parameters of Fruits and Vegetables

Textural parameters of fruits and vegetables are perceived with the sense of touch, either when the product is picked up by hand or placed in the mouth and chewed. In contrast to flavor attributes, these characteristics are fairly easily measured using instrumental methods. Most plant materials contain a significant amount of water and other liquid-soluble materials surrounded by a semi-permeable membrane and cell wall. The texture of fruits and vegetables is derived from their pressure, and the composition of individual plant cell walls and the middle lamella "glue" that holds individual cells together. Cell walls are composed of cellulose, hemicellulose, pectic substances, proteins, and in the case of vegetables, lignin. Tomatoes are an example of a fruit vegetable that is approximately 93–95%water and 5–7% total solids, the latter comprised of roughly 80–90% soluble and 10–20% insoluble solids. The greatest contributor to the texture of tomato products are the insoluble solids, which are derived from cell walls. The three-dimensional network of plant cell walls is still unresolved, but is a topic of great interest to scientists in that to a large degree it dictates the perception of consistency, smoothness, juiciness etc. in fruit and vegetable tissues .

According to Bourne (1982) the textural properties of a food are the "group of physical characteristics that arise from the structural elements of the food, are sensed by the feeling of touch, are related to the deformation, disintegration and flow of the food under a force, and are measured objectively by functions of mass, time, and distance." The terms texture, rheology, consistency, and viscosity are often used interchangeably, despite the fact that they describe properties that are somewhat different. In practice the term texture is used primarily with reference to solid or semi-solid foods; however, most fruits and vegetables are viscoelastic, implying that they exhibit combined properties of ideal liquids, which demonstrate only viscosity (flow), and ideal solids, which exhibit only elasticity (deformation).

Adhesiveness	Gumminess
Chewiness	Hardness
Cohesiveness	Rupture strength
Consistency	Springiness
Crispiness	Stiffness
Crunchiness	Stringiness
Elasticity	Texture profile analysis
Extensibility	Toughness
Firmness	Work to cut
Fracturability	Work to penetrate
Gel strength	Work to shear

Source: Adapted from Brown, r.d., 2010. Food Texture Analysis.

Table 1: Parameters That Can Be Measured Using a Texture Analyzer

2.8 Texture Perception

Texture perception begins with the structure of a food material (i.e. how the molecules or microstructures are arranged geometrically). When this structure is put in to the mouth or manipulated with our hands, it undergoes changes such as size reduction and moistening caused by salivation. The food structure, together with masticatory action, produces stimuli, which are converted by neural factors into a texture response from the brain. These responses can be converted into intensity ratings of certain textural attributes, which are usually rated by trained sensory panels. Food texture is a cognitive property assigned to foods on the basis of how senses interact with the food by vision, touch, and oral processing. Therefore, food texture is perceived during the conversion of food structure into a bolus through a complex series of oral manipulations including ingestion, processing, and swallowing. Food texture provides a physical barrier to ingestion, as foods must be masticated to a degree of size, structure, and lubrication that prepares them for safe swallowing (Van, 2009). Through this, food texture influences eating rate and, in recent years, attention has turned to the importance of fast and slow eating rates in moderating energy intake. A met analysis of eating rate studies has confirmed that eating rate is associated with higher energy intakes, and may be an important contributor to positive energy balance and weight gain.

Furthermore, texture responses can be converted into preference evaluations, typically rated by consumers [10]. In addition to texture perceptions that occur in the mouth, vision, touch, and audition also play important roles in texture perceptions. Visual texture is the first textural attribute that is noticed when evaluating textural properties of foods. Visual texture judgments are largely dependent on prior eating experiences. Vision creates expectations of the texture in the mouth or in the hands. If these expectations are violated, the food may be rejected [11].Textural properties that can be evaluated visually include shine, and surface roughness and reflection, to mention but a few. Tactile sense, i.e. the sense of touch, is also used for texture evaluations. Texture evaluations can be made either directly, mainly by touching or manipulating the food material with the fingers or indirectly by touching the food with a knife, fork etc. Introduced a list of texture attributes that can be used for describing the, 'hand feel' properties of paper and fabric. These attributes can be adapted to food product evaluations. Texture attributes that can be evaluated manually include mechanical (such as force to compress), geometrical (gritty, fuzzy), and moisture (oily, wet) attributes. Most of these texture properties are perceived by contact between skin and material surfaces.

Moving skin (e.g. finger) across the surface (e.g. skin of an orange) sets up vibrations in the skin which are thought to be a critical sensation in tactile texture perceptions. It has been demonstrated that it is possible to differentiate textural properties of food samples, such as cheeses, using either hand or mouth evaluations. Lips are also important for tactile texture perception. They are especially sensitive to assessing surface roughness and other related food attributes (Heath and Prinz, 1999). However, when it comes to evaluating the degree of certain textural attributes (e.g. crispness), evaluations done in the mouth are found to be more exact than those done with the hands.

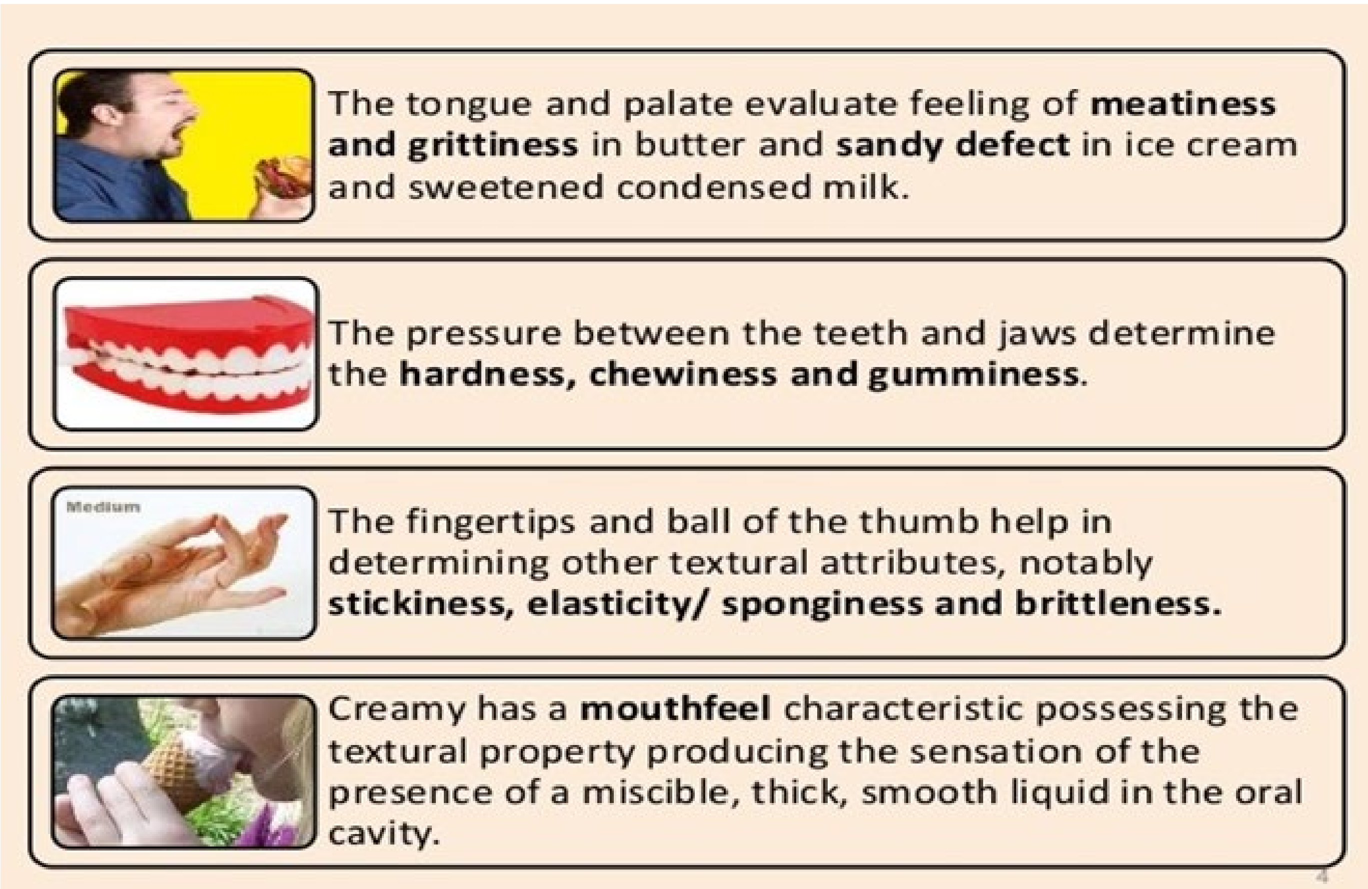

Figure 2: Characteristics of Texture and the Place of Determination and the Evaluation

2.9 Classification of Sensory Food Texture Attributes

The terms 'structure' and 'texture' commonly appear when considering food texture, and they are sometimes confused with each other. Both have specific meanings. The structure of the food can be defined as "the nature of and relationship between component parts of a body or material". The word texture again is defined as "the attribute of a substance resulting from a combination of physical properties, which are perceived by the senses of touch (including kinaesthetic and 'mouthfeel'), sight, and hearing. Physical properties may include size, shape, number, nature, and confirmation of constituent structural elements. Texture perceptions are caused by food structure [10,12]. And structure can be classified into four levels based on how it is observed. These classes are chemical, electron microscopic, light microscopic and gross observation. The chemical structure deals with the molecules that make up the food and how these molecules interact with each other. The electron microscopic level has to do with the aggregation of molecules and their assembly into components, and the light microscopic level deals with the same items on a larger size scale.

3. Texture-Flavor Interactions

3.1 Texture Effects on Basic Tastes

Texture sensation does not merely occur as a response to teeth, isolated from other stimuli. In a normal eating situation, interactions between texture, taste, and aroma take place. One of the most well-known texture-taste interactions is that increasing viscosity reduces perceived taste intensity. Studied the effects of carboxyl methyl-cellulose and gelatin solutions on perceived sweetness and bitterness the study demonstrated that increasing consistency of the samples reduced the perceived intensity of these two tastes. A similar effect was found when thickness of tomato juice, orange drink, and coffee was increased with hydrocolloids, reducing perceived tastes of sourness and bitterness. This reduction effect is hydrocolloid-, drink- and taste-specific. For example in case of sweetness, produced by sucrose and fructose, taste reduction. Caused by increasing viscosity is based on the physiologic fact that to be tasted the sugar compound must diffuse to the surface of the taste buds on the tongue. The diffusion rate is dependent on the mobility of the tasting in the matrix and thus depends on the concentration of the tasting and the rheological properties of the thickener used [13].

3.2 Texture Effects on Odor

In addition to texture-taste interactions, texture affects odor perceptions obtained by sniffing orthonasally. According to Pang born and Szczesniak (1974), the addition of hydrocolloids in water solutions generally reduces odor intensity. A similar finding was made with beverages: an increase in hydrocolloid concentration reduced aroma intensity remarkably. The reason suggested for odor reduction was that the large hydrocolloid molecules entangle and trap to small odor molecules, which results in reduced vapor pressure of the solutions. It was supposed that the texture-odor interactions are linked to molecule size and to polarity and volatility of the odor and flavor). More recent literature has shown that increasing hydrocolloid concentration reduces the partition coefficients of volatile compounds. The reduction is caused by interactions between particular volatile molecule and particular hydrocolloid [14].

3.3 Texture Effects on Flavor

Besides texture interactions with basic taste and odor, texture-flavor interaction has been reported. In the case of normal eating and sensory evaluation, flavor is usually defined as perception of taste and aroma together, obtained retro-nasally in the mouth during eating. Taste and odor interactions occur when evaluating flavor. Cliff and Noble (1990) noticed that increasing glucose (tastant) level raised the fruitiness (flavor) evaluations of glucose-aroma water solutions, even though the aroma (peach) level maintained stabile. Vice versa, when aroma level was raised, the sweetness evaluations increased regardless of constant glucose level. Similar results have been obtained with different aromas and tastings. Thus, tastes are capable to increase aroma intensities and conversely, aromas may increase taste sensations (Noble, 1996). Tactile sensations play also significant role in flavor perception (Noble, 1996). In general, an increase in food viscosity reduces perceived flavor intensity. Indicate that increasing gelatin concentration of gel-type samples resulted in decreased perceived sensory flavor intensity. Similar results were obtained by Guinard and Marty (1995), who demonstrated that firm gels released flavor of lower intensity than soft gels. In addition to diminished flavor intensity, increasing mechanical strength of the gel-type samples results in prolonged flavor perception. This may partly be due to the total surface area of a firm sample available for flavor release increasing at a slower rate during mastication than that of a fragile sample. Thus, the total chewing time needed to masticate firm samples is also longer than that needed for fragile samples.

As described above, texture affects taste, odor and flavor perceptions of foods. Furthermore, different tastants have been reported to have effects on perceived textures. Sucrose has been demonstrated to increase physically measured viscosity of hydrocolloid solutions, whereas sodium chloride and caffeine decrease apparent viscosity. Citric acid, in turn, decreases both apparent and physically measured viscosity of similar hydrocolloid solutions. The addition of a specific flavorant (butyric acid) has also been shown to reduce the sensory and physically measured viscosity of hydrocolloid samples. Thus, all interactions discussed above are tastant, aroma and texture specific, and all food components together determine the how taste, odor, flavor and texture of foods are perceived [11,15].

4. Measurement of Food Texture

4.1 Trained Sensory Panels

Sensory evaluations of texture produce information on how people perceive and react to texture when using products [15]. To obtain reliable and objective sensory measurements, trained sensory panels are needed for texture evaluations. Without appropriate training, subjects use their own frames of references in the evaluation. These objectives references differ because of different sensory experiences, cultural background, environment factors, and general personal history. Through training, it is possible to develop a common frame of reference to be used during evaluations. Such a panel would be able to provide similar qualitative and quantitative responses.

4.2 Consumers Texture Profile

The consumer texture profile method is recommended by (1975) when consumers' texture perceptions, other than liking, are of interest. The method uses a list of descriptive texture terms developed by a trained texture profile panel. The terms 'good' and 'bad' are added to the list to obtain an overall measure of texture quality. The subjects are asked to evaluate given attributes on a 6-point scale anchored 'not at all' – 'very much so'. The problem is that consumers may not understand all the texture attributes as similarly as the trained panelists do. A common opinion is that consumers can evaluate a few "simple" texture attributes (like hardness), but more technical attributes (like factorability) are not suited for consumer testing. To evaluate these "simple" attributes, the relative-to-ideal scale is recommended. The scale is anchored from, for example, 'not nearly too hard' to 'much too hard', with 'just right' being in the middle. The scale measures the desirability and optimum levels of attributes from a consumer point of view.

4.3 Texture Profiling

Since texture is a multi-parameter attribute, as evidenced by a large number of words used to describe it, it is only logical to try to introduce some order and classify these terms' sensations into certain categories. An attempt at doing this is shown in Tables 1 and 2 for solids and semi- solids and Table 3 for liquids [17]. The classification of textural terms for solids and semi-solids gave rise to a profiling method of texture description (TPA) applicable to both sensory and instrumental measurements with the sensory method the evaluation includes several steps outside and inside the mouth, from the first bite through mastication, swallowing and residual feel in the mouth and throat. Its use is based on standard scales for the mechanical parameters which are also employed for selecting and training of panel members [16].

The scale covers the entire range of hardness found in food products, from cream cheese at the low end to rock candy at the high end. It was recommended that when testing specific products the scale should be expanded in the intensity range covered by the test products. Experience gained in subsequent practical applications of these scales led to some modifications and development of additional scales described in a publication by Munoz (1986). With the instrumental method, texture profiling involves compressing the test substance at least twice and quantifying the mechanical parameters from the recorded force-deformation curves. With temperature sensitive foods, e.g. gelatin gels or chocolate, the profiling should be extended to temperature and tests performed at several temperature levels.

Texture Profile Analysis is a popular double compression test for determining the textural properties of foods. It is occasionally used in other industries, such as pharmaceuticals, gels, and personal care. During a TPA test samples are compressed twice using a texture analyzer to provide insight into how samples behave when chewed. The TPA test was often called the "two bite test" because the texture analyzer mimics the mouth's biting action. The textural identity of any food is rarely a simple matter of understanding a singular attribute such as hardness or cohesiveness. The texture of any food is multi-faceted and tied to consumers' sensory expectations. It is not sufficient to deliver a food with a target hardness and springiness value if consumers do not like it and it does not meet their expectations for that food type.

5. Conclusion

Food texture is a collective term of sensory experiences originated from visual, audio and tactile stimuli. The sensation of food texture plays a crucial role in influencing consumers' liking and preference of a food product. Consumer concern and interest of food texture vary from one type of food to another. For solid foods, sensory experience associated with fracture and breaking could be the most relevant textural features, whereas the sensation of flow behavior could be the most critical texture-related feature for fluid foods. For semisolid or soft solid foods, different patterns of stress–strain deformation provide key information for the delicate texture variation among this type of food. Food texture and food structure are the two internally linked properties. Although food structure influences textural properties of a food, it is regarded as material property of the food. The term food texture has a strong inclusion of sensory experience. Ingredient interactions and food processing and preparation are the most important industrial approaches for food texture (or food structure) creation or modification. Moisture content and fat content are the two key determining factors for texture creation. Content of air, as expressed as structure openness, also plays a critical role in texture creation. Using these parameters as three dimensions, foods can be conveniently grouped for their textural properties.

It is only when food physics interacts with oral physiology that the sensation and perception of food texture becomes possible. The underpinning principles of food texture sensation are very different from that of taste and aroma. Mechanoreceptors are the key for the detection of texture stimuli. However, the interpretation of these sensory stimuli is a very complicated internal process where the underlying psychophysical principles are still not fully understood [18-52].

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References

1. Cardello, A. V., Bell, R., & Kramer, F. M. (1996). Attitudes of consumers toward military and other institutional foods. Food quality and Preference, 7(1), 7-20.
2. Pascua, Y., Koç, H., & Foegeding, E. A. (2013). Food structure: Roles of mechanical properties and oral processing in determining sensory texture of soft materials. Current Opinion in Colloid & Interface Science, 18(4), 324-333.
3. Fawole, O. A., & Opara, U. L. (2013). Harvest discrimination of pomegranate fruit: Postharvest quality changes and relationships between instrumental and sensory attributes during shelf life. Journal of Food Science, 78(8), S1264-S1272.
4. Stieger, M., & van de Velde, F. (2013). Microstructure, texture and oral processing: New ways to reduce sugar and salt in foods. Current opinion in colloid & interface science, 18(4), 334-348.
5. Stokes, J. R., Boehm, M. W., & Baier, S. K. (2013). Oral processing, texture and mouthfeel: From rheology to tribology and beyond. Current Opinion in Colloid & Interface Science, 18(4), 349-359.
6. Hemsley, B., Palmer, S., Kouzani, A., Adams, S., & Balandin, S. (2019). Review informing the design of 3D food printing for people with swallowing disorders: Constructive, conceptual, and empirical problems.
7. Sungsinchai, S., Niamnuy, C., Wattanapan, P., Charoenchaitrakool, M., & Devahastin, S. (2019). Texture modification technologies and their opportunities for the production of dysphagia foods: A review. Comprehensive Reviews in Food Science and Food Safety, 18(6), 1898-1912.
8. McCrickerd, K., & Forde, C. G. (2016). Sensory influences on food intake control: moving beyond palatability. Obesity Reviews, 17(1), 18-29.
9. Krop, E. M. (2019). The influence of chewing and oral lubrication on satiety using hydrogels (Doctoral dissertation, University of Leeds).
10. Hutchings, J. B., & Lillford, P. J. (1988). The perception of food texture-the philosophy of the breakdown path. Journal of Texture Studies, 19(2), 103-115.
11. Szczesniak, A. S., & Kahn, E. L. (1971). Consumer awareness of and attitudes to food texture: I: Adults. Journal of Texture Studies, 2(3), 280-295.
12. Jowitt, R. (1974). The terminology of food texture. Journal of Texture Studies, 5(3), 351-358.
13. Kokini, J. L. (1985). Fluid and semi-solid food texture and texture-taste interactions. Food technology (USA).
14. Godshall, M. A. (1997). How carbohydrates influence food

flavor. Food technology.
15. Lawless, H. T., Heymann, H., Lawless, H. T., & Heymann, H. (2010). Texture evaluation. Sensory evaluation of food: principles and practices, 259-281.
16. Civille, G. V., & SZCZESNIAK, A. S. (1973). Guidelines to training a texture profile panel. Journal of texture studies, 4(2), 204-223.
17. Brandt, M. A., Skinner, E. Z., & Coleman, J. A. (1963). Texture profile method. Journal of food science, 28(4), 404-409.
18. Bourne, M. (2002). Food texture and viscosity: concept and measurement. Elsevier.
19. Campbell, C. L., Wagoner, T. B., & Foegeding, E. A. (2017). Designing foods for satiety: The roles of food structure and oral processing in satiation and satiety. Food Structure, 13, 1-12.
20. Rosenthal, A. (Ed.). (2015). Modifying Food Texture: Novel Ingredients and Processing Techniques. Woodhead Publishing.
21. Chung, C., & McClements, D. J. (2015). Structure and texture development of food-emulsion products. In Modifying food texture (pp. 133-155). Woodhead Publishing.
22. Cliff, M., & Noble, A. C. (1990). Time-intensity evaluation of sweetness and fruitiness and their interaction in a model solution. Journal of Food Science, 55(2), 450-454.
23. Dar, Y. L., & Light, J. M. (Eds.). (2014). Food texture design and optimization. John Wiley & Sons.
24. De Roos, K. B. (2003). Effect of texture and microstructure on flavour retention and release. International Dairy Journal, 13(8), 593-605.
25. De Wijk, R. A., & Prinz, J. F. (2005). The role of friction in perceived oral texture. Food Quality and Preference, 16(2), 121-129.
26. Dick, A., Bhandari, B., Dong, X., & Prakash, S. (2020). Feasibility study of hydrocolloid incorporated 3D printed pork as dysphagia food. Food Hydrocolloids, 107, 105940.
27. Foegeding, E. A., Vinyard, C. J., Essick, G., Guest, S., & Campbell, C. (2015). Transforming structural breakdown into sensory perception of texture. Journal of Texture Studies, 46(3), 152-170.
28. Guo, C., Zhang, M., & Bhandari, B. (2019). Model building and slicing in food 3D printing processes: a review. Comprehensive Reviews in Food Science and Food Safety, 18(4), 1052-1069.
29. Huang, M. S., Zhang, M., & Bhandari, B. (2019). Assessing the 3D printing precision and texture properties of brown rice induced by infill levels and printing variables. Food and Bioprocess Technology, 12, 1185-1196.
30. International Organization for Standardization (ISO). Sensory Analysis—Methodology—Texture Profile (IS0 11036); ISO: Geneva,Switzerland, 2020.
31. JAIME, I., MELA, D. J., & BRATCHELL, N. (1993). A study of texture-flavor interactions using free-choice profiling. Journal of sensory studies, 8(3), 177-188.
32. Koç, H., Vinyard, C. J., Essick, G. K., & Foegeding, E. A. (2013). Food oral processing: conversion of food structure to textural perception. Annual review of food science and technology, 4, 237-266.
33. Koeferli, C. R. S., Piccinali, P., & Sigrist, S. (1996). The influence of fat, sugar and non-fat milk solids on selected taste, flavor and texture parameters of a vanilla ice-cream. Food Quality and Preference, 7(2), 69-79.
34. Kramer, A. (1975). Food texture—definition, measurement and relation to other food quality attributes. Theory, determination and control of physical properties of food materials, 55-64.
35. Kremer, S., Mojet, J. O. S., & Kroeze, J. H. (2005). Perception of texture and flavor in soups by elderly and young subjects. Journal of texture studies, 36(3), 255-272.
36. Lawless, H.T. and Heymann, H., 1999. Texture evaluation. In Sensory evaluation of food (pp. 379-405). Springer, Boston, MA.
37. Le Tohic, C., O'Sullivan, J. J., Drapala, K. P., Chartrin, V., Chan, T., Morrison, A. P., ... & Kelly, A. L. (2018). Effect of 3D printing on the structure and textural properties of processed cheese. Journal of Food Engineering, 220, 56-64.
38. Lu, R. (2013). Principles of solid food texture analysis. In Instrumental assessment of food sensory quality (pp. 103-128). Woodhead Publishing.
39. McClements, D. J. (2020). Future foods: Is it possible to design a healthier and more sustainable food supply?. Nutrition Bulletin, 45(3), 341-354.
40. Mouritsen, O., & Styrbæk, K. (2017). Mouthfeel: how texture makes taste. Columbia University Press.
41. Norton, I. T., Spyropoulos, F., & Cox, P. (Eds.). (2010). Practical food rheology: an interpretive approach. John Wiley & Sons.
42. O'Sullivan, M. G. (2017). Instrumental assessment of the sensory quality of food and beverage products. A Handbook for Sensory and Consumer-Driven New Product Development; O'Sullivan, MG, Ed, 151-175.
43. Opportunities for the production of dysphagia foods: A review. Compr. Rev. Food Sci. Food Saf. 2019, 18, 1898–1912.
44. O'sullivan, C. A., Bonnett, G. D., McIntyre, C. L., Hochman, Z., & Wasson, A. P. (2019). Strategies to improve the productivity, product diversity and profitability of urban agriculture. Agricultural Systems, 174, 133-144.
45. Oyinloye, T. M., & Yoon, W. B. (2021). Stability of 3D printing using a mixture of pea protein and alginate: Precision and application of additive layer manufacturing simulation approach for stress distribution. Journal of Food Engineering, 288, 110127.
46. Pereira, T., Barroso, S., & Gil, M. M. (2021). Food Texture Design by 3D Printing: A Review. Foods 2021, 10, 320.
47. Rapisarda, M., Valenti, G., Carbone, D. C., Rizzarelli, P., Recca, G., La Carta, S., ... & Finchiaro, S. (2018). Strength, fracture and compression properties of gelatins by a new 3D printed tool. Journal of Food Engineering, 220, 38-48.
48. Rosenthal, A. J., & Rosenthal, A. J. (1999). Food texture: measurement and perception.
49. Sila, D. N., Duvetter, T., De Roeck, A., Verlent, I., Smout, C.,

Moates, G. K., ... & Van Loey, A. (2008). Texture changes of processed fruits and vegetables: potential use of high-pressure processing. Trends in food science & technology, 19(6), 309-319.
50. Smith, J. V. (2000). Textural evidence for dilatant (shear thickening) rheology of magma at high crystal concentrations. Journal of Volcanology and Geothermal Research, 99(1-4), 1-7.
51. Tan, C., Toh, W. Y., Wong, G., & Li, L. (2018). Extrusion-based 3D food printing–Materials and machines. International Journal of Bioprinting, 4(2).
52. Van Der Bilt, A. (2009). Oral physiology, mastication and food perception. In Designing functional foods (pp. 3-37). Woodhead Publishing.