Impact of oral processing on texture attributes and taste perception

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Abstract Mastication is the first step of food digestion, where foods are broken down and simultaneously impregnated by saliva resulting in the formation of semi-fluids known as food boluses. This review focuses on the impact of oral processing on texture attributes and taste perception. The article describes the oral actions in which texture characteristic are measured for the critical conditions that trigger swallowing. Taste perception also plays a key role in oral processing and oral sensations. There are still challenges in terms of determining different oral physiological characteristics. These include individual chewing behavior regardless of the temporal aspects of dominant processes of comminution, insalivation, bolus formation and swallowing. A comprehensive approach is essential to process favorable foods with respect to the food properties of texture and taste.

Keywords Oral processing · Fracture · Bolus formation · Swallow · Texture perception · Taste perception

Introduction

Food processing is a rigorous and important means of structural adjustment. Food oral processing includes all muscle activities, jaw movements, and tongue movements that contribute to preparing food for swallowing. The processed foods which is not only support the enjoyment and pleasure of consumption but also provide energy and essential nutrients (Chen 2009). Typical food processing involves selecting a variety of raw materials and mixing with other food additives, forming a constant desirable structure which can be stored (Chen 2015). However, food oral processing is the reverse of this process. Figure 1 provides a conceptual framework of the dominant food physics, sensory and physiological parameters during oral processing of solid food. The whole food form is reduced to increasingly small and more numerous small particles (Salles et al. 2011; Selway and Stokes 2014). Food begins a structural degradation and disintegration leading to a special microstructure and texture suitable for swallowing. The fundamental properties of food oral consumption include mechanical fragmentation of teeth while using the extrusion of tongue–palate and combining with saliva formation (Harrison and Cleary 2013; Neyraud et al. 2003). Using research techniques, it is possible to follow the process of reducing the whole food to a swallowable bolus. As food oral processing occurs, rheological properties play an important role more so than the fracture characteristics depending on the matrix' transformation to a bolus (Selway and Stokes 2014). Both fracture characteristic and rheological properties of the food matrix make contribution to sensory perception, in particular texture perception which is likely to influence consumers' acceptance and preference (Foster et al. 2011).

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Fig. 1 Conceptual framework of oral processing

Pre-mastication and fracture mechanics are mostly based on the food's internal structure, whether it is soft or hard. Foods including solids, semi-solids or even liquids have impact on individuals' chewing behavior as well as temporal dominant sensation (TDS) in mind (Devezeaux de Lavergne et al. 2015; Saint-Eve et al. 2015). Generally, compared to soft solids, an increased number of chewing cycles and a greater amount of muscle force are required for the harder solids (Woda et al. 2006). Bolus properties including moisture content and particle size are measured at different stages of food oral residual time and help to explain the mechanics of trigger swallowing (Motoi et al. 2013; Rodrigues et al. 2014).

Food oral processing is extremely complex and taste perception is affected by the influence of food ingredients as well as physiology and the human mind. Once entering the mouth, foods may break into pieces after chewing and the taste substances are dissolved and hydrated in the local saliva, and then spreaded in the whole oral cavity due to the extrusion of the palate and the movement of the tongue. Taste compounds at a certain concentration of aqueous solution can be perceived at the saliva-receptor interface by the human body (Tian and Fisk 2012). While, the target taste perception should be interfered from the other taste ingredients.

The aim of this work is to primarily focus on mechanical characteristics of the whole food oral processing, especially the periods of bolus formation and swallowing, and try to explain the properties of bolus development. Particle size,

oral physiology and the saliva mixture as it influences sensory perception also reviewed, including texture perception and taste perception. Better understanding of how foods behave in the mouth and how food is sensed by individuals is necessary, which can be helpful for product development. Therefore, the objective of the review is to understand the impact of oral processing on texture/taste perception so that a better product can be created and research gap can be identified.

Food texture perception

Pre-mastication and fracture mechanisms

Food texture associated with food oral breakdown and deformation is determined by complex rheological properties and muscle movement applied with force. Designing and manipulating the whole food integrate all components to obtain a desirable uniform structure and taste. For the research of food oral processing, texture evaluation turns out to be complicated measuring actions in the mouth as well as sensory evaluation (Hutchings and Lillford 1988). Degree of food structure is one of the key factors affecting the perception of food texture inside the mouth. Food inside the mouth during mastication has been characterized via a simple visual flowchart, in which there are approximately four stages, including transportation, mastication, bolus formation and deglutition (Lucas et al. 2002). From

comminution to agglomeration, hydration and dilution, normal food has degenerated into pieces from a solid integrity. With the breaking and chewing of a food, texture sensory is spontaneously perceived, directly linked to its fracture characteristics. The fundamental fracture properties of hardness and crunchiness of sensory perceptions during oral processing directly rely on the amount of stress required to initiate and propagate a crack in the material. Generally, three-point bending test and single edge notched bend test are used to explain the complex changes of bolus fracture properties during oral food processing. In the first moments of masticatory action, the fracture attributes of solid food create significant textural sensations. In addition, the food breaking and fracture mechanics are based on the mechanical properties of each element during mastication and have been quantitatively measured using EMG (electromyography), the three-dimensional jaw tracking (electrognathography) (Chen 2009) and modified texture profile analysis (Kim et al. 2012). By comparing to EMG and the three-dimensional jaw tracking, it is possible to measure the motion of jaw movement by video recording. The movement between the chin and nose determines the number of chews and the time of food retention (Motoi et al. 2013). The process of combining the first two methods to explain the relationships among mechanical properties, sensory perception and oral physiology during chewing has been widely used to determine solid food firmness, deformability and stickiness of cheese, caramel (Çakır et al. 2012), biscuits (Kim et al. 2012) and model gels (Çakır et al. 2012). As the chewing sequence progresses, the food mechanical characteristics have been dramatically changed depending on its microstructural breakdown. The increase in the food toughness or the resistance to cracking or breaking in a material leads to an increase in the chewing cycle length in the initial cycles of masticatory sequence and markedly influences jaw movement patterns (Foster et al. 2006; Reed and Ross 2010; Woda et al. 2006). In the latter moments of oral processing, changing of food springiness, firmness and chewiness, texture properties correlating with food force–deformation behavior discourage food breaking down (Türker et al. 2007; Trulsson 2006), at the same time muscle activity, number of chews and chewing sequence of sensory panels are altered. Firmer model gels require a lot more number of chews and a long chewing sequence, in which greater amplitude of jaw opening and closing muscle activities are observed. In contrast, softer model gels from mastication to swallowing require less muscle activities, while increases in the cohesiveness produce a negative impact on the number of chews and the chewing sequence duration (Çakır et al. 2012).

Attempts are made to determine the variation in physical characteristics, which is associated with the pressures

applied on food, based on the difference of hard and soft solid food microstructure and the decrease of particle size in the subsequent breaking and comminution. Solid food inside of the mouth experiences large structure changes (whole-granules-bolus) with saliva promoting the aggregation of particles, which directly links to its microstructure. Rodrigues et al. (2014) observed the microstructure of biscuit bolus spitted-out at the swallowing point and concluded that laminar mixing governed bolus formation using the light microscopy and the cryo-scanning electron microscopy (cryo-SEM). Particles measured in the following comminution suggested that particle size increased but particle number decreased under the multiple function of tongue–teeth–palate squeezing and saliva secretion which softened and lubricated the food particles (Rodrigues et al. 2014).

In order to understand the texture sensation of cheese (a soft material) based on the oral processing action from the initial stages to the time of swallowing, the temporal dominance of sensation (TDS) has been used. Furthermore, principal component analysis (PCA) has also been used for sensory data analysis. Microstructural cheese were evaluated using six different levels of fat, dry matter and pH (Saint-Eve et al. 2015). Ten sensation criteria attributes were selected to describe the cheese samples at each stage of consumption: melting, liquid, mouth coating, soft, residual film, sticky, fat, hard, brittle-gel and thick. Different texture characteristics were evident at different perception sequences of the different cheeses. A “soft” perception was always realized as first dominant property and a “cheese residue” perception was dominant in the bolus ready-to-swallow phase. Divided into two groups on the basis of fat concentration, the TDS curves revealed that the lower fat group dominated “fat” perception at the end of food consumption while the high fat group dominated in the middle of chewing phase. The characteristic of “brittle-gels” dominated for two low-fat cheeses in the intermediate stage of oral processing compared to three high-fat cheeses which were characterized with the term of “thick”, as indicated by crosses on each cheese’s trajectory. Previous study has also indicated that full-fat cheese broke down into more pieces with chewing action and its bolus turned out to be more cohesive and smoother compared to the low-fat ones (Çakır et al. 2012).

The diversity of oral physiology at different periods of human aging results in various food sensory perceptions. Different age groups’ chewing behavior varies: breaking, chewing frequency and saliva secretion. Fracture properties of nuts (Hutchings et al. 2014) and potato chips (Luckett et al. 2016), including hardness, crispness and brittleness, has been explored for sensory perception in different age groups. Compared to younger people, older people need more time to select a first characteristic and change fewer.

Hardness is generally dominant during mastication instead of brittle, sticky, and oily characteristics (Hutchings et al. 2014). To examine the effect on mastication patterns from different crispness levels of potato chips, several flavors of chips include plain, cheese and spicy were used with three age groups: younger (20–25 years), middle-aged (40–45 years) and older (65+ years) adults. Seven main parameters were analyzed, including chew work, average chew work, average chew max, number of chews, average chew duration, average duration between chews and time to deglutition using EMG. There is a significant interaction between flavor type and age group with respect to the number of chews. An increase in raising crispness levels in chips leads to a longer chewing time for the older adults. However, beyond the older group, people who have a difficulty or even inability in swallowing are due to the inability to control the speed of liquids through the pharynx—a condition defined as dysphasia (Cichero 2013). Food texture modifying and fluids thickening are the most common methods to smoothing and simplifying the oral processing procedure (Andersen et al. 2013; Cichero 2013).

Bolus formation

Bolus formation is a crucial procedure during food consumption involving rhythmical jaw movements and saliva secretion, which occupies most of the time and simultaneously leads to sensory perception as well as energy and enjoyment. Undergoing turbulence but regular transformation, the bolus adapts continuously throughout a chewing sequence to reform a floating sticky mixture from an integral dry food with the help of teeth's occlusion-opening, tongue's movement and the addition of saliva, determining whether granules are adequately small and the extensibility and viscosity of bolus is suitable for swallowing. Particle size has been studied in ten different natural foods, including both hard and soft materials, chewed and expectorated just before swallowing (Jalabert-Malbos et al. 2007). They determined whether the hardness or the softness should accomplish deglutition safely and efficiently with the bolus degraded into a majority of small particulates (<2 mm) or into numerous larger particulates (>2 mm). Perhaps a loss of numerous particulates during whole mastication, especially its latter stages, caused an undeveloped recognition, whereby the amounts of small particulates were always increasing. Recent studies show how the distribution of apparent particle size of biscuit bolus is related to moisture content and texture properties at different masticatory time (Rodrigues et al. 2014; Young et al. 2013). Rodrigues et al. (2014) discovered comminution dominated the beginning of chewing sequences (10% mastication) for small-sized crumbs (<5 mm) holding most of the biscuit bolus. Then crumbs developed paste

like agglomerates, whereby biscuit crumbs were further broken down and absorbed/swelled saliva in order to possess sufficient moisture content to be easy to swallow. As a results, the oral behavior from 10 to 50% mastication resulted in an increase of macro fragments (20–40 mm) while a decrease of the number of tiny chips (0–5 mm) in the aggregate occurred. Additionally, there was a drastic parabolic growth of bolus moisture content as the disintegration and digestion processes. This result differed from the findings by Motoi et al. (2013) to some extent, which showed the moisture content of the bolus increased linearly during mastication. The possible reasons were the difference of individual physiology and chewing habits. Not only does the rise of moisture makes it easier to swallow the bolus, but also it makes a difference on texture perception (Young et al. 2013).

To explain the impact on mastication from multiple components of various solid foods, the particle size distributions of five foods, including cake, cereal bar, muesli bar, cooked pasta and peanuts of two portion sizes have been measured. Bolus samples were expectorated at the point of swallowing as well as residual 'debris' then washed with TRIS buffered saline (Flynn et al. 2011). The results showed that cake had an overall smaller particle size compared to pasta using PCA. Thus, the results showed that softer materials were more likely to hold larger particles than the harder ones (Rodrigues et al. 2014). Pasta required a more intense comminution account for higher cohesiveness and chewiness than brittle peanuts with a fundamental link between bolus properties and texture.

There are convoluted correlations among the bolus water-holding capacity, chewing behavior and physical characteristics at different stages of oral processing. Both water content of the food itself and saliva addition expedite bolus formation. Thus, to determine the impact of initial food moisture content on oral consumption, duck cake and white bread with various moisture levels were investigated. It was determined that moisture content has a positive relationship with its initial food moisture at the swallowing point yet is negatively correlated with saliva addition (Motoi et al. 2013). Moreover, adding water or not just prior to mastication generated an enormous impact on the number of chewing strokes (NCS) observed via EMG as well as physical properties using texture profile analysis (TPA) (Shiozawa and Kohyama 2011). There is always a phenomenon occurred when a lower NCS coincides with a water presence rather than the absence of water in the latter stages of mastication. Hardness always dominates the duration from early to middle chewing time in biscuits bolus production regardless of water added or not, and bolus without added water produces a significant high degree of hardness relative to the other. However, this is not the same in case of rice cakes where there was higher

initial moisture content. We inferred that probably the potential reason was that boli can easily and effectively absorb water at the very beginning of oral consumption. As food oral disintegration progress, there are no significant differences in the adhesiveness and cohesiveness of two different types of food during the later oral processing. This period also requires lower NCS because the mixture is more liquid and suitable for swallowing. Many studies have similar results where a clear link occurred between moisture content and texture perception. Vickers et al. (2014) measured the sensory texture characteristics of five types of almond forms conditioned at four different moisture levels to explore individual preference. They found crispiness, crunchiness, and reduction of crunch depended on the moisture content increasing during consumption. This affected consumers texture preference ratings (Vickers et al. 2014).

In most cases, the solid-matrix undergoes continuous comminution and extrusion, absorbing saliva and coalescing into a bolus with rheological properties just before swallowing. Water in food and saliva precipitate semi-solids even glutinous-liquids, which lead to the dominant position of rheological and the lubricating properties on texture characteristics in the later stages as they flow smoothly and efficiently through the oral cavity (Engelen and de Wijk 2012; Le Bleis et al. 2013). Le Bleis et al. (2013) measured rheological behavior of two bread bolus spit out for different time periods and found that the consistency index (K) decreased significantly during food residual time by means of capillary rheometry, implying bolus were formed from crushed small pieces and decentralized into saliva like viscoelastic-plastic. Similarly, the value of storage modulus (G') decreased versus oral processing time measured by oscillatory rheometry, whereas the differences of G' were marked higher. So, we deduced that an increase of heterogeneity by virtue of small particle size and an appropriate amount of saliva (especially mucoprotein) may be one of the reasons resulting in different results of rheology. Fluids with higher viscosity are due to a higher level of proteins (Hadde et al. 2015). Tribological characteristics of dairy products at different fat levels and the transformation to temporal oral sensation were described by Nguyen et al. (2016). The variable physical characteristics variation was also applicable to cereal food (Loret et al. 2011).

Unlike solid foods, the liquid foods often exist in the form of emulsion droplets or particles dispersed during the food processing inside the mouth without requiring a large amount of chewing and comminution. As a result, texture and flavor perception largely depend on its flow behavior and colloidal stability of dispersed particles. The distribution of positively and negatively charged emulsions as well as interactions between them, accompanied by oral

shearing, pH and temperature changes, play a major role in determining oral destabilization. One may feel dryness and a rough oral sensation based on a higher viscosity and lubrication caused by a modulated microstructure and the rheological attributes of emulsions mixed with salivary proteins in an eating process (Chen 2014). The oral sensation contributes to the flexible movement of the tongue, which provides assistance in transporting emulsion droplets to cover every corner of the oral cavity and facilitates interactions between particles leading to a perception of “soft coating” or “velvety coating” (Camacho et al. 2015). Moreover, sensations of smoothness, creaminess, fattiness and slipperiness are influenced by the impact of droplet size in low viscosity emulsions (Sonne et al. 2014). Regardless of the complex components of natural emulsions, various emulsion-filled gels were used to explain the influence of mechanical characteristics on mastication and dynamic texture sensation (Devezeaux de Lavergne et al. 2016). Harder gels (with a high concentration of gelling agent) often obtain a sensation of firm and grainy in general for a large amount of crumbs. A decrease in the concentration of gelling agent produces a more fluid sensation of melting, refreshing and creamy during oral consumption.

The tendency towards certain properties of texture is still unclear depending on the physiology and experience of individual's behavior which determines granules' aggregation and adhesion on oral surfaces. To confirm that there are any significant differences in these factors regarding bolus properties-including texture, physiological characterizations in chewing, the stimulated salivary flow rate, masticatory performance, oral and pharyngeal volumes, these factors have been used to improve the understanding of the limitation of physiological structure on texture sensation by pinpointing the most important contributory factors (Saint-Eve et al. 2015). Particularly, Alsanei et al. (2015) highlight that tongue muscle strength is a major powerful driver of the capability of food breaking which significantly impacts texture preference and subsequent oral handling (durations towards bolus and swallow). Moreover, individual human differences in the masticatory and hydration behaviors concerning the analytical dynamics of bolus formation by measuring masticatory efficiency, oral cavity volumes, salivary α -amylase activity and sodium content in saliva were observed during different bread consumption (Panouillé et al. 2014). The physical measurements of both brittle and glutinous solid boluses, mainly as the density of food, adhesiveness and cohesiveness changed a lot because of different human chewing behaviors, especially the volume of food in the mouth that may potentially expedite the evolution of a swallowable food bolus (Goto et al. 2015). An appropriate eating behavior needs to be clarified to describe different mastication capacity. Reasonable texture-modified food could be

conducted using different individual groupings namely the elderly, dysphagia patients and infants etc.

Triggering a swallow

A swallow is the terminal point after food undergoes a round of transportation from crushing and squeezing to shaping and forming a bolus under the highly coordinated oral action. Before the moment, the mechanical physico-chemical natures of the bolus have been changed significantly as a decreased particle size and the addition of a mixture of saliva. The above changes in structure and motility play an enormous role in promoting a spontaneous swallow. Hutchings and Lillford (1988) proposed only if really does match three factors before a swallow is triggered: a sufficient chewing time, critical particle size and adequate oral lubrication. All of these together produced a perfect swallow. Attempts are already underway to support this theory (Engelen et al. 2005; Jalabert-Malbos et al. 2007). Furthermore, the rheology properties, especially flow-ability and stretch-ability of bolus just before swallowing were measured in large complex fluid foods (Chen and Lolivret 2011). They found that there is a direct relationship between apparent shear viscosity and the difficulty of swallowing. The ability of bolus to stretch significantly gives rise to the sense of easiness. Similarly, the moisture content of food bolus could be served as an indication of reaching a swallow for different cereal food boluses containing about 50% water, regardless of significant variations in subjects' oral physiological system and chewing behavior (Loret et al. 2011). Additionally, food oral retention time does drastically affect the difficulty levels for swallowing. Human individuals possess varied capacities of mastication and swallowing, which decide the duration of food oral consumption time and salivary secretory volume. There are no significant differences in the number of chewing cycles before swallowing.

Oral taste sensing perception

Taste perception as another important property which is realized once food enters the mouth whereas texture is one of food oral processing natural sensory characteristics. It is manipulated via chewing to achieve the enhancement of contact with the oral cavity. More generally, taste sensation is a physical sense and a mental perception related to consumption of food taste substance mixed with saliva. Effect of chewing has a significant impact on taste compounds released. Both the original food (released after the structures destroyed by chewing) and new taste substances produced during mastication (enzymolysis of saliva) produce taste by dissolving in saliva and food water entering

taste bud cells. The pattern in which the components respond by dissolving and hydrolyzing at the different stages of simple digestion is important. Mastication stimulates the gustatory nerve endings and allows the motor program to feedback to the brain to capture oro-taste through hydration in the saliva (Neyraud et al. 2005).

The importance of saliva on food oral processing has attracted increased attention because of its crucial role in influencing eating behavior and sensory perception. As well there is a tendency of consumer preference depending on its ingredients, in particular α -amylase and lingual lipase. As food enters the mouth, it can stimulate saliva secretion during the food breaking, shaping and bolus formation as well as the biodegradation of the food item resulting in the taste components being released into the mouth. Therefore, taste sensing perception is derived from the dynamic process of continuous or non-continuous dissolution and degradation of food materials handled inside the mouth.

Basic taste sensation

The human mouth is a very subtle induction system, which can detect different kind of excitement and some range of stimulation intensities. Chemoreceptor as one of the main receptors in the mouth relevant to diet and sensory perception can experience different taste substances and they are widely distributed in the surface of the tongue, especially in the front, sides and rear of the tongue (Chen 2014). In natural food oral processing, a complex progression of changes took place in the mouth whereby taste ingredients released to create a complex but multilevel sensation including perceptual interactions of sweet, bitter, salty, sour, umami and even oleogustus (Kulkarni and Mattes 2014) and starchiness (Lapis et al. 2016).

Food autochthonous elements is one of the most important factors that impact taste intensity. For example, Neyraud et al. (2003) suggested increases in salt content led to a shorter chewing time which stimulated more saliva secretion and promoted the release of other taste substances as ultimately observed. Furthermore, Syarifuddin et al. (2016) linked the saltiness perception and fat content perception for cheese-like solid food products to the cross-modal interactions (odour-taste-texture) and found that the resulting aroma can only significantly elevate taste intensity in the mind. In addition, sugar is another food taste and composition when combined with fat and salt during oral consumption can increase the prevalence of diet-related diseases at a higher level and influence humans' health and fitness (Arancibia et al. 2013). Sweetness of food is not only related to the sugar content in a product, but also related to the speed of its spread in oral cavity. Sugar particles present in food interacting with saliva in the

mouth during consumption allowed the body to perceive sweetness (Tournier et al. 2009). The sweetness is likely to affect by the food texture significantly, or under certain circumstances, masked by the other ingredients in a product, for a partial inhibition on the diffusion speed of stimulus. Studies have shown that the more viscous or harder, the lower value of sweetness is sensing (Hoppert et al. 2012). Thus, acceptable sensation characteristics will also be greatly enhanced by the interactions of a variety of taste compounds consumption and how they relate to texture attributes during the residual time that the food enters the mouth until swallowing.

Chewing behaviors of individuals is another factor influencing taste intensity, including: chewing time, extrusion of teeth–tongue–palate and saliva secretion. Arancibia et al. (2013) highlighted eating behavior of eight different dairy desserts and differences of thickeners to some extent and find that food oral consumption could increase the delivery of sucrose molecules with the effects of some physicochemical and cognitive interactions (Arancibia et al. 2013). There are in a total 30 types of enzymes in the saliva and α -amylase was one of the most important enzymes, which is mainly responsible for oral digestion of starch (Salles et al. 2011). This is the main cause of human oral perception of sweetness. Mosca et al. (2015) found that the differences in bolus sweetness intensity were due to the sucrose heterogeneously distributed in layers of gels having different fracture characteristics. They suggested this leads to different contact areas for gel crumbs which scatter throughout the entire oral cavity. A more significant function of fracture strain on eating behavior and sweetness intensity can be explained by the formation of many more small crumbs while enhancing the frequency of stimulation of taste receptors. The enhancement of the taste intensity of gels demonstrates the importance of the oral breakdown behavior (mainly changes in fracture properties) transition to temporal taste perception. All starch-based products are in general being shown to achieve a higher sweetness intensity than the CMC-based (carboxymethyl cellulose) ones perhaps because of the activity of saliva enzymes, mainly α -amylase, leading to a decreased thickness in the mouth feel.

Comparing with oral sensation, sensory perception is influenced by physiological, psychological and cultural factors. Human sensory response is extremely complex and is non-linear and non-uniform, time-dependent, and interactive and combinatorial (Chen 2014). However, we still believe that the target sensory characteristic of feelings could be disturbed by the existence of other sensory stimuli (Hoppert et al. 2012). There are no established sensory characteristics laws on food consumption from food

entering the mouth till a swallowing, due to the interference of various food ingredients stimulate.

The sixth taste: oleogustus and starchy

Oleogustus

With the thorough study of food oral processing, lingual lipase—a special enzyme in saliva which many consider to aid the hydrolysis of triglycerides gained the special attention of food sensory scientists. Furthermore, there may be a potential mechanism suggested by some scholars of human perception of fat: free fatty acids into the special taste bud cells produce oleogustus (Kulkarni and Mattes 2014). However, there are still arguments of the existence of oleogustus defined to be a mixed stimulation of bitterness and sourness. They thought that the effect of enzymatic hydrolysis on fat was marginal for a low lingual lipase levels. While the functions of CD36 (a lipid—binding protein located in tongue epithelial cells) as scavengers as well as the receptors of lipid make oleogustus a possibility to be the sixth taste besides sweetness, bitterness, saltiness, sourness and umami (Dransfield 2008; Khan and Besnard 2009; Mattes 2011; Pepino et al. 2012). Thus, the research of oleogustus will increase quickly due to various points of view.

Attempts are being made to detect oleogustus (Hogenkamp and Schiöth 2013; Rolls 2011). This particular taste alone instead of its texture (viscosity) in the mouth and aroma is going to be measured in order to determine the extent to which it contributes to taste perception during oral processing even though it seems to be more susceptible to food structure, aroma, temperature and some aspects of organoleptic properties. Saltiness release will be weakened due to a food's natural fat content achieving a state where subjects' recognition ability to basic taste sensation will decline, where there are relationships between saltiness and other tastants (Chabanet et al. 2013). Consequently, there will be a significant influence on food oral processing and human health issues.

Starchy

Starchy has competed for the sixth taste besides Oleogustus. Study showed that one can taste oligosaccharide definitely without using sweet receptor (Lapis et al. 2016). This taste may be a sense of staple food namely starchy. The specific chemical oligosaccharide contributes to the uptake of energy for humans. Once found this taste receptor, its taste could be identified.

Competition is continuing for the sixth taste. More researches are needed to explore this area.

Conclusion

Food oral consumption is a highly coordinated and dynamic process involving the interactions of tongue, teeth and palate. There is much research devoted to the mechanisms of oral mastication. Food materials undergo a dramatic structure change from the first bite to the point of swallowing, where the size of particles changes and numerous particles coalesce to form a complete bolus. During the process, saliva is secreted and dispersed over the total oral surface area triggering swallowing. There is a complete transformation from a solid food to a soft moist food.

Pre-mastication and fracture properties (fracture stress and fracture strain) of materials dominate the physics of food and oral physiology during the early stages of food degradation. There are a number of studies concerning the mechanical and chemical properties in the latter periods in terms of bolus formation and the point of swallowing. Furthermore, releasing tastants inside the mouth greatly influences oral sensation in the mind. When food enters the mouth, flavor ingredients promote the development of many and complex oral sensations as mastication and the addition of saliva with the interactions among various tastant compounds. While, discussions of middle stages of food residual time are still rare because of its complexity and it is difficult to understand. There is needed more research for improvement in understanding this process.

There are many uncontrollable factors in food oral processing, especially individual human differences and different eating behaviors, chewing force and saliva secretion. However, it makes no difference to the mechanical properties including moisture content and rheology characteristics of the bolus just before swallowing. In addition, individual human differences also influence taste perception during food degradation. Another problem is that studied objects in oral processing are mostly emulsions and model gels. These may not comprehensively describe the physical and chemical changes of foods like meat, fruit and vegetables and so on. These areas deserve more special attention.

Texture and taste perception are two aspects in food oral processing leading to consumers' acceptance and preference of food. However, there are a huge number of unique populations (the elderly, neuro-dysphagia etc.) in the world and it is important to design and manufacture products with favorable texture and taste considering their eating behavior, particularly the ability of mastication and swallow.

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