PPP annual report 2019
PPPs which have started under the direction of the top-sectors need to deliver an annual report regarding their research and financial progress. For reporting on research progress this format has to be applied. A separate format 'PPP final report' is available for PPPs that have finalized in 2018.
Annual reports are entirely published on the TKI/topsector website(s). Please prevent the incorporation of confidential matter in the report.
PPP annual reports have to be submitted - pooled for each research organisation - before 1 March 2020 to the TKIs at info@tkitu.nl, or at info@tki-agrifood.nl. For Wageningen Research the delivery of reports occurs centrally.

General data	
PPP number	**AF-15504**
Title	**Smooth Bite for All**
Theme	**Gezond&Veilig**
Executing research organisation(s)	**Wageningen University and Research**
Project leader research (name + email address)	**Dr. Markus Stieger** **markus.stieger@wur.nl**
Coordinator (on behalf of private parties)	**Michiel Sytsma** **sytsma@tifn.nl**
Contact person of government	**Unknown**
Total project budget (k€)	**2500**
Project website address	**-**
Starting date	**01-05-2016**
Final date	**30-06-2020**

Approval coordinator/consortium The annual report has to be discussed with the coordinator/consortium. The TKI(s) like to be informed regarding potential comments on the annual report.	
The annual report is …… by the coordinator on behalf of the consortium	□ approved □ not approved
Potential comments regarding the final report	

Brief description content/aim PPP What is the matter and what does the project contribute? What does the project deliver and what are the effects of its delivery?
The aim of the project is to determine the influence of structural and textural food properties and expectations of foods on bolus properties, oral processing behavior, dynamic sensory perception and liking in consumer groups varying in age, ethnicity and eating capability. The project delivers scientific knowledge on interrelationships between food structure and structural heterogeneities, bolus properties, food oral processing, expectations, sensory and emotion perception and liking in consumers varying in age, ethnicity and eating capability. The project delivers guidelines for food industry to efficiently and selectively stratify and customize product formulations targeted for specific consumer groups.

Results 2019 Give a brief description of the high-lights in 2019.
The scientific highlights of six studies which were completed in 2019 within the "Smooth Bite for All" project are summarized in the following:

1) We studied the effect of inhomogeneity in oil droplet distribution at different length scales on the mechanical and sensory properties of emulsion-filled food gels. Two approaches were followed to obtain an inhomogeneous distributions at different length scales: (1) clustering of o/w-emulsions by hetero-aggregation and subsequent gelation to obtain inhomogeneity at µm-scale, and (2) incorporating particles of emulsion-filled gels into emulsion-filled gel matrices with a different volume fraction of oil droplets to obtain gel-in-gels with inhomogeneity at mm-scale. Upon clustering of oil droplets at µm-scale, the Young's modulus of the gels increased by up to 60%, whereas fracture stress and strain depended on emulsifier-matrix interactions. Clustering of oil droplets affected mainly the perception of texture-related sensory attributes, such as hardness, but did not significantly affect the perception of fat-related sensory attributes. Fat-related sensory attributes, such as creaminess and melting, were dominated by emulsifier matrix interactions. For gel-in-gels, the inhomogeneous distribution of oil droplets at mm-scale did not affect Young's modulus or fracture strain. The incorporation of particles decreased the fracture stress of the gels, independently of the droplet distribution. The perception of fat-related sensory attributes changed significantly. Oiliness was lower in samples with lower oil content in the outer phase of the gel than in the inner dispersed particles, whereas coating perception increased in samples in which the oil droplet distribution was inhomogeneous, independently on whether the outer phase or the inner gel particles contained a higher oil volume fraction. Creaminess was only slightly affected. We conclude that oil droplet clustering at µm-scale can be used to modify mechanical properties and texture-related perception of emulsion-filled gels, whereas inhomogeneity at mm-scale allows altering fat-related sensations. Sensory perception can be controlled by modifying the interactions between dispersed oil droplets and matrix using different emulsifiers and by incorporating inhomogeneity in the oil droplet distribution of emulsion-filled gels at different length scales.

2) Food oral processing depends on food properties and consumer characteristics. The aim of this study was to determine the effect of age, gender, ethnicity and eating capability on oral processing behaviour of liquid, semisolid and solid foods. Oral processing behaviour of 18 commercially available foods, ranging from liquids, semisolids to solids, was compared between Dutch, Caucasian adults (18-30 yrs), Chinese, Asian adults (18-30 yrs), Dutch, Caucasian elderly (60-80 yrs), and consumers with mild swallowing problems and/or low mastication efficiency (18-80 yrs). Participants were video recorded during food consumption and six oral processing parameters extracted. Elderly consumed all foods with lower eating rates (g/s) than young adults by increasing consumption time (s). Females consumed solid foods with lower eating rates (g/s) than males by reducing bite size (g). Chinese, Asian consumers consumed liquid and solid foods with lower eating rates (g/s) than Dutch, Caucasian consumers by reducing bites size (g). Chinese, Asian consumers consumed semi-solid foods with lower eating rates (g/s) than Dutch, Caucasian consumers by reducing bite size (g) and increasing consumption time (s). Consumers with decreased mastication efficiency or mild swallowing problems showed similar oral processing behaviour than healthy consumers, probably because reduction in eating capability was limited in the group. This demonstrates that different consumer groups adapt eating rate (g/s) in different ways by modifying bite size (g), consumption time (s) or both. To conclude, age, gender and ethnicity influence oral processing behaviour of liquid, semi-solid and solid foods differently. Understanding differences in oral processing behaviour of specific consumer groups can assist in steering sensory perception, food choice and energy intake of specific consumer groups such as the elderly.

3) This study explored how product familiarity and physiological characteristics of participants affect detectability of microparticles in viscous and semi-solid foods. Cellulose particles differing in size (50–780 µm) were added (1.5% w/w) to two dairy products, quark (viscous curd cheese) and processed cheese. Discrimination thresholds for added microparticles were determined by 47 Dutch, Caucasian and 45 Chinese, Asian women using the Method of Constant Stimuli. Particle size detection thresholds did not significantly differ between the two groups, but differed significantly between the two products. Detection threshold estimates for particle size were lower in viscous, low-fat quark than in semi-solid, high-fat processed cheese (52 µm versus 86 µm). This suggests that particle detection depends on product properties such as product consistency and composition, but not on factors linked to ethnicity and/or nationality of participants. We found no evidence to support a relationship between product familiarity and particle size detection thresholds in either product. A positive but weak correlation was found between stimulated saliva flow and particle size detection threshold in processed cheese ($r = 0.21$, $p = 0.041$), suggesting active salivation might enhance sensitivity for microparticle detection in semi-solid foods. PROP status and fungiform papillae density did not correlate with particle size detection threshold for either food. We conclude that matrix properties were the main contributors to particle size detection thresholds in young, healthy participants who differed in nationality and ethnicity. These data suggest that product characteristics are the central factor that should be considered for

modifications when dealing with foods in which particles lead to negative sensations such as grittiness.

4) This study investigated the effect of mechanical contrast and particle flavour concentration of carrot particles added to soups on expected and perceived sensations and liking. The properties of a chicken soup were varied by addition of real carrots, model carrots and model chicken particles differing in size, fracture stress, and/or carrot flavour concentration. The four aims of the study were: (1) To study the effect of mechanical contrast on expected and perceived sensations; (2) To investigate the role of particle carrot flavour concentration on perceived sensations and liking; (3) To study the effect of dis/confirmation of expected by perceived sensations on liking; (4) To investigate the consumer's preferences and ideal profile of soups. Expected sensory properties were affected by particle size: the larger the particles, the higher the expected intensities for hardness, chewiness, and crunchiness of soups. Perceived sensory properties were significantly influenced by size and fracture stress of carrot particles. Increasing flavour concentration in model carrot particles added to soups marginally influenced liking suggesting that flavour concentration in particles added to soups has a limited effect on liking. When model carrot particles were added to soups, expected sensory properties were confirmed by perceived sensory properties, and consequently liking did not change considerably. The congruency and familiar appearance of the model carrot pieces probably contributed to the confirmation of expectations. When model chicken pieces were added to soups, expected sensory properties were disconfirmed by perceived sensory properties leading to a significant decrease in liking. Soups containing medium-sized, soft carrot particles were the closest to the consumer's ideal product profile. To summarize, consumer expectations and physicochemical properties of chicken and carrot particles added to chicken soup contributed to perception and liking of soups. We conclude that the sensory product profile of common products such as soups can be optimised by addition of congruent and familiar particles that match consumer' expectations.

5) Practical approaches to increase consumption of healthy foods such as vegetables are needed. Controlling eating rate is a promising strategy, since faster eating rates have been related to higher food intake. Food properties can be modified to influence eating rates, but little is known about the impact of vegetable dimensions and condiment additions on eating rates of vegetables. This study determined the influence of shape, size and condiment properties on eating behavior towards carrots. Eating behavior (mastication time, number of chews, chewing frequency, eating rate) was determined for carrots with same total weight but different shapes (cube, julienne), and varying in size, number of pieces and aspect ratio. Carrots presented in one large cube required the lowest mastication effort (shortest mastication time, fewest chews) among all pre-cut carrots. Carrot cubes required less mastication effort leading to higher eating rates than carrots julienne. To investigate the effect of condiment addition on eating behavior towards carrots, mayonnaises varying in fat content and viscosity were combined with carrots, and mastication behavior and bolus properties were determined. Mayonnaises, in particular those with high fat content or low viscosity, contributed to faster bolus formation of carrots. Carrots were swallowed with less particles of larger sizes when mayonnaises were added. These results indicate that a specific particle size is not a prerequisite to induce swallowing, and that other bolus properties such as lubrication or cohesiveness trigger the urge to swallow. We conclude that eating behavior towards carrots can be controlled by relatively small changes in both carrot and condiment properties. To increase carrot intake by increasing eating rate, we suggest to avoid cutting of carrots or to add condiments, which could be an effective strategy to increase vegetable consumption or to decrease mastication effort to target the elderly population.

6) Foods with condiments such as bread with spreads or vegetables with dips are frequently consumed. The aim of this study was to understand how dynamic and static sensory perception changes when foods are consumed together with condiments. Two carriers (bread, carrot) varying in hardness were combined with condiments (mayonnaises) varying in fat content and viscosity to obtain model composite foods. Dynamic sensory perception was assessed using Temporal Dominance of Sensations (TDS) with attribute lists describing both carrier- and condiment-related attributes. Static sensory perception was evaluated using Rate-All-That-Apply (RATA) with attribute lists descriptive for either bread, carrot or mayonnaise. Carrier foods (bread, carrot) had a larger influence on dynamic and static sensory perception of carrier-condiment combinations than condiments (mayonnaises). Sensations related to mayonnaises (sour, creamy) were dominant at later stages of consumption when these were combined with harder bread or carrots. Hard bread or carrots reduced intensities of several mayonnaise-related attributes (sour, dairy when combined with bread; creamy, after taste when combined with carrots) to a larger extent than soft bread or carrots. Consumer sensitivity to discriminate between foods was not affected

by the presence of other food items when differences in bread, carrots or mayonnaise properties were large. In case of smaller differences between food properties, consumer sensitivity to discriminate between foods declined and depended on the food type it was combined with. We conclude that the product properties of both solid carrier foods and condiments and their interaction during consumption impact dynamic and static sensory perception of carrier-condiment combinations.

Number of delivered products in 2019 (give titles and/or description of products, or a link to the products on the project website, or other public websites).

Scientific articles	Reports	Articles in professional journals	Lectures/workshops/ posters
7	2	-	43

Titles/descriptions of prominent products in 2019 and their targets groups

16 scientific papers in peer-reviewed Q1 journal for academics and food industry:

16. Ketel, E.C.; de Wijk, R.; de Graaf, C.; Stieger, M. (2020) Relating oral physiology and anatomy of consumers varying in age, gender and ethnicity to food oral processing behaviour. Physiology & Behaviour (accepted)

19. Santagiuliana, M.; Broers, L.; Sampedro Marigómez, I.; Stieger, M.; Piqueras-Fiszman, B.; Scholten, E. (2019) Strategies to compensate for undesired gritty sensations in foods. Food Quality and Preference (in press)

15. Fuhrmann, P.L.; Sala, G.; Stieger, M.; Scholten, E. (2019) Effect of oil droplet inhomogeneity at different length scales on mechanical and sensory properties of emulsion-filled gels: Length scale matters. Food Hydrocolloids (in press)

14. Fuhrmann, P.L.; Aguayo-Mendoza, M.G.; Jansen, B.; Stieger, M.; Scholten, E. (2019) Characterisation of friction behaviour of intact soft solid foods and food boli. Food Hydrocolloids (in press).

13. van Eck, A.; Wijne, C.; Fogliano, V.; Stieger, M.; Scholten, E. (2019) Shape up! How shape, size and addition of condiments influence eating behaviour of vegetables. Food & Function. 10. - p.5739-5751.

12. Santagiuliana, M.; Marigómez, I.S.; Broers, L.; Hayes, J.; Piqueras-Fiszman, B.; Scholten, E.; Stieger, M. (2019) Exploring variability in detection thresholds of microparticles through participant characteristics. Food & Function 10 (9). – p. 5386-5397.

11. van Bommel, R.; Stieger, M.; Boelee, N.; Schlich, P.; Jager, G. (2019) From first to last bite: Temporal dynamics of sensory and hedonic perceptions using a multi-intake approach. Food Quality and Preference. 78. – p. 103748.

10. Fuhrmann, P.L.R.; Kalisvaart, L.C.M.; Sala, G.; Scholten, E.; Stieger, M. (2019) Clustering of oil droplets in o/w emulsions enhances perception of oil-related sensory attributes. Food Hydrocolloids 97. – p. 105215.

9. Doyennette, M.; Aguayo-Mendoza, M.G.; Williamson, A.M.; Martins, S.I.F.S.; Stieger, M. (2019) Capturing the impact of oral processing behaviour on consumption time and dynamic sensory perception of ice creams differing in hardness. Food Quality and Preference. 78. – p. 103721.

8. Santagiuliana, M.; Scholten, E.; Piqueras-Fiszman, B.; Stieger, M. (2019) Don't judge new foods by their appearance! How visual and oral sensory cues affect sensory perception and liking of novel, heterogeneous foods. Food Quality and Preference. 77. –p. 64-77.

7. Fuhrmann, P.L.R.; Sala, G.; Stieger, M.; Scholten, E. (2019) Clustering of oil droplets in o/w emulsions: Controlling cluster size and interaction strength. Food Research International. 122. – p. 537-547.

6. Ketel, E.C.; Aguayo-Mendoza, M.G.; de Wijk, R.A.; de Graaf, C.; Piqueras-Fiszman, B.; Stieger, M. (2019) Age, gender, ethnicity and eating capability influence oral processing behaviour of liquid, semi-solid and solid foods differently. Food Research International. 119. – p. 143-151.

5. Santagiuliana, M.; van den Hoek, I.A.F.; Stieger, M.; Scholten, E.; Piqueras-Fiszman, B. (2019) As good as expected? How consumer expectations and addition of vegetable pieces to soups influence sensory perception and liking. Food & Function. 10. – p. 665-680.

4. van Eck, A.; Fogliano, V.; Scholten, E.; Stieger, M. (2019) Adding condiments to foods: How does static and dynamic sensory perception change when bread and carrots are consumed with mayonnaise? Food Quality and Preference 73. – p.154-170.

3. van Eck, A.; Hardeman, N.; Karatza, N.; Scholten, E.; Fogliano, V.; Stieger, M. (2019) Toppings assist saliva in bolus formation: Oral processing behavior and dynamic sensory perception of bread and crackers with and without toppings. Food Quality and Preference. 71. – p. 497-509.

2. van Bommel, R.; Stieger, M.; Schlich, P.; Jager, G. (2019) Dutch consumers do not hesitate: Capturing implicit 'no dominance' durations using Hold-down Temporal Dominance methodologies for sensations (TDS) and emotions (TDE). Food Quality and Preference 71. – p. 332-342.

1. Aguayo-Mendoza, M.G.; Ketel, E.C.; van der Linden, E.; Forde, C.G.; Piqueras-Fiszman, B.; Stieger, M. (2019) Oral processing behavior of drinkable, spoonable and chewable foods is primarily determined by rheological and mechanical food properties. Food Quality and Preference 71. – p. 87-95.

Annex: Titles of deliverables or a link to products on the project website or other public websites

1) Aguayo-Mendoza et al. Oral processing behaviour of drinkable, spoonable and chewable foods is primarily determined by rheological and mechanical properties. Food Quality and Preference 71 (2019) 87–95.

2) Santagiuliana et al. Mechanical properties affect sensory detectability of texture contrast in heterogeneous food gels. Food Hydrocolloids 80 (2018) 254-263.

3) Santagiuliana et al. Effect of mechanical contrast on sensory perception of heterogeneous liquid and semi-solid foods. Food Hydrocolloids 83 (2018) 202-212.

4) van Eck et al. Oral processing behavior and dynamic sensory perception of composite foods: Toppings assist saliva in bolus formation. Food Quality and Preference. (2019) doi: https://doi.org/10.1016/j.foodqual.2018.05.009

5) Van Bommel et al. Dutch consumers do not hesitate: Capturing implicit 'no dominance' durations using Hold-down Temporal Dominance methodologies for sensations (TDS) and emotions (TDE). Food Quality and Preference 71 (2019) 332-342.

6) Santagiuliana, M.; van den Hoek, I.A.F.; Stieger, M.; Scholten, E.; Piqueras-Fiszman, B. (2019) As good as expected? How consumer expectations and addition of vegetable pieces to soups influence sensory perception and liking. Food & Function (in press)

7) van Eck, A.; Fogliano, V.; Scholten, E.; Stieger, M. (2019) Adding condiments to foods: How does static and dynamic sensory perception change when bread and carrots are consumed with mayonnaise? Food Quality and Preference (in press)