5th International Conference on

Food Oral Processing

July 1st – 4th

Book of Abstracts

University of Nottingham, 2018

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Conference Programme

Monday July 2nd

8.30am	**Conference Opening and Introduction**	Dame Jessica Corner, Pro Vice-Chancellor, University of Nottingham	*Chair – Ian Fisk*
9.00am	**Progress and Challenges of Food Oral Processing – Looking Back and Forward**	Jianshe Chen, Chair of Food Oral Processing Committee	
9.45am	**Flash Posters (3 minutes each):** P7 - The Influence of Salivary Metabolites on Oral Perception (Alexander Gardner, King's College London Dental Institute) P13 - Saliva esterase activity during wine oral processing: inter-individual differences, effect of wine composition and impact on wine odorant esters (Maria Angeles Pozo-Bayón Instituto de Investigación en Ciencias de la Alimentación (CIAL), CSIC-UAM) P25 - How valid is 50 s-1 for measuring viscosity of liquids? (Jane Jun Xin Ong, University of Guelph) P32 - Effect of mechanical contrast on sensory perception of heterogeneous liquid and semi-solid foods (Marco Santagiuliana, Wageningen University & Research) P41 - Instrumental compression test of soft food gels between a soft artificial tongue and a hard plate (Kaoru Kohyama, Food Research Institute, NARO) P48 - The extent of oral processing determines the nutritional value of bread: an in vitro investigation (Jing Gao, National University of Singapore) P64 - Measuring baby's oral motor patterns and trends with baby food snacks (Sarah Smith-Simpson, Nestle Nutrition, Fremont, MI) P65 - Role of food oral processing as a driver of pizza liking: a new insight into the design of healthy and appreciated ultra-processed food (Isabelle SOUCHON, INRA AgroParisTech)		*Chair – Bettina Wolf*
10.10am	**Morning Break**		
10.35am	**The Influence of Oral Processing on Food Perception**	Andries van der Bilt, University Medical Center, Utrecht	*Chair – Christopher Vinyard*
11.05am 11.05-11.20 11.20-11.35 11.35-11.50 11.50-12.05	**Theme 1 & 2 - Oral Physiology and Dentistry (10 minutes each plus 5 mins questions):** 1.1 - Inclusion of the initial phase of mastication for determining chewing efficiency using a solid test food (Hilbert W. van der Glas, Zhejiang Gongshang University) 1.2 - Oral Peri-Receptor Events Affecting Salt Taste Sensitivity (Theresa Stolle, Technische Universität München) 1.3 - Which variables should be controlled when measuring the granulometry of a chewed bolus? Results from a quantitative synthesis (Guillaume Bonnet, Université Clermont Auvergne)		

	1.4 - Impact of oral health on masticatory efficiency and kinematics in young children (Natacha Linas, Centre de Recherche en Odontologie Clinique (CROC))		
12.05pm	**Lunch**		
1.05pm	**Oral Food Processing: a Dental Perspective**	Nikolaos Giannakpoulos, University Clinic of Wurzburg, Germany	*Chair – Andries van der Bilt*
1.35pm	**Improving Oral Health or Changing Food Texture: The Challenge for Persons with Neuromotor Disabilities**	Martine Hennequin, University of Clermont Auvergne, France	
2.05pm 2.05-2.20 2.20-2.35 2.35-2.50 2.50-3.05 3.05-3.20	**Theme 1 & 2 - Oral Physiology and Dentistry (10 minutes each plus 5 mins questions):** 2.1 - Exposure to chocolate almond milk likely increases human salivary expression of proline rich proteins (Cordelia Running, Purdue University) 2.2 - Unravelling the effects of interindividual variability of human saliva on aroma compounds (Carolina Muñoz-Gonzalez, Centre des Sciences du Goût et de l'Alimentation) 2.3 - Responses of the Salivary Proteome to Transient Receptor Potential Channel Agonists (Jack Houghton, King's College London) 2.4 - Discrimination of chocolate texture varies with individual differences in oral somatosensation (John E Hayes, Penn State) 2.5 - Linking oral processing behaviour to oral physiology of consumers varying in age, gender and ethnicity (Eva Ketel, Wageningen University)		
3.20pm	**Afternoon Break**		
3.45pm	**From Food Texture to Global Perception: Respective Impacts of Food and Human Physiology**	Elisabeth Guichard, INRA Paris	*Chair – Gilles Feron*
4.15pm 4.15-4.30 4.30-4.45 4.45-5.00 5.00-5.15 5.15-5.30 5.30-5.45	**Theme 3 - Food Texture During Consumption (10 minutes each plus 5 mins questions):** 3.1 - Toppings facilitate oral processing behavior of bread and crackers (Markus Stieger, Wageningen University) 3.2 - Temporal aspects of cream cheese texture perception using Temporal Dominance of Sensations (TDS) tool (Dian Widya Ningtyas, The University of Queensland) 3.3 - From first to last bite: Emotions change from high to low arousal and dominant sensations built-up during multiple bite assessment of yogurt (Roelien van Bommel, Wageningen University) 3.4 - On relating rheology and oral tribology to sensory properties in hydrogels (Emma Krop, University of Leeds) 3.5 - Evolution of bolus granulometry and bioaccessibility of proteins during mastication of chopped and non-chopped beef meat (Anne Duconseille, Université Clermont-Auvergne) 3.6 - Carbonation as a novel taste-free thickener increases swallowing time (Jeyam Emmanuel, King's College London Dental Institute)		

5.45-6.00	3.7 - Modifying gluten-free bread structure by different baking conditions: impact on oral processing and sensory perception (Patricia Puerta, Institute of Agrochemistry and Food Technology (IATA-CSIC))	
6.00-6.15	3.8 - Temporal Dominance of Motions: a new concept to enlighten the links between texture perceptions and oral processing (Anne Saint-Eve, AgroParisTech)	
6.15-6.30	3.9 - Texture-dependent mastication behaviors of the elderly with a different dental status (Weon-Sun Shin, Hanyang University)	
6.30pm	**Close**	

6.30-7.30pm - FOP Committee meeting

7.30pm – Dinner at the Orchard Hotel

Tuesday July 3rd

8.30am	**Nuts Just Take Up Space Where Chocolate Ought to Be: Food Complexity and Oral Breakdown**	Bryony James, University of Auckland	*Chair – Bettina Wolf*
9.00am	**Theme 4 - Food Physics during consumption (10 minutes each plus 5 mins questions):**		*Chair – Marco Morgenstern*
9.00-9.15	4.1 - Chewing behavior of high-protein expanded pea flour (Christian Salles, INRA)		
9.15-9.30	4.2 - Mechanical properties affect detectability of perceived texture contrast in heterogeneous food gels (Marco Santagiuliana, Wageningen University & Research)		
9.30-9.45	4.3 - Modulation of taste intensity using heterogeneous distribution of taste active molecules in liquid foodstuffs (Benjamin Le Révérend, Nestlé Research Center)		
9.45-10.00	4.4 - Oral processing behavior of composite foods: interplay between carrier and topping properties (Arianne van Eck, Wageningen University)		
10.00-10.15	4.5 - Dynamic flavor release from chewing gum: mechanisms of release (Igor Bodnar, Firmenich S.A)		
10.15am	**Morning Break**		
11.00am	**Theme 4 - Food Physics during consumption (10 minutes each plus 5 mins questions):**		*Chair – Bettina Wolf*
11.00-11.15	4.6 - Tribological Study on Saliva-Tea Compound Mixture: Correlation between Hui Gan (Sweet Aftertaste) Perception and Friction Coefficient (Chong Pik Han, Zhejiang Gongshang University)		
11.15-11.30	4.7 - Oral tribology of protein microgel particles: Influence of hydrophobicity of contact surfaces (Dr. Anwesha Sarkar, University of Leeds)		
11.30-11.45	4.8 - Clustering of oil droplets in o/w emulsions enhances sensory perception of oil related attributes (Elke Scholten, Wageningen University & Research)		
11.45am	**Individual Variation in Taste Perception: What Happens When We Thermally Stimulate the Tongue?**	Joanne Hort, Massey University	
12.30pm	**Lunch**		

2.00pm	**Using Functional MRI to Understand Individual Variations in Taste Perception**	Sue Francis, University of Nottingham	*Chair – Markus Stieger*
2.30pm 2.30-2.45 2.45-3.00 3.00-3.15 3.15-3.30	**Theme 5 - Food Texture Insights through Analytical Assessment in-vivo, ex-vivo, in-vitro (10 minutes each plus 5 mins questions):** 5.1 - Biomechanical characterization of tongue-food interface during oral processing: an in vitro study with Quantitative Ultrasound (Vincent Mathieu, AgroParisTech, INRA) 5.2 - Mechanical insights into the textural perceptions of model beverages – a multivariate approach (Piyali Chakraborty, University of Queensland) 5.3 - Relating acoustic tribology to in vitro tribology, oral coating and sensory perception (Ann Stijnman, NIZO) 5.4 - Can in vitro and in silico studies help us understanding the motor control of swallowing? (Marco Marconati, University of Surrey)		
3.30pm	**Afternoon Break**		
4.00pm	**Oral Processing and Its Impact on Metabolic Outcomes**	Jeyakumar Henry, Clinical Nutrition Research Centre, National University of Singapore	*Chair – Ann-Marie Williamson*
4.30pm 4.30-4.45 4.45-5.00 5.00-5.15 5.15-5.30	**Theme 5 - Food Texture Insights through Analytical Assessment in-vivo, ex-vivo, in-vitro (10 minutes each plus 5 mins questions):** 5.5 - Probing the in-mouth texture perception with a biomimetic tongue (Jean-Baptiste Thomazo, Sorbonne Université/Nestlé) 5.6 - Effect of α-Amylase on Instantaneous Rheological Properties of Tapioca Starch (Shen Siung Wong, Tate & Lyle) 5.7 - Estimation of physical quantities on human organ surface during oral and swallowing process using novel measurement system "F-bology® analyzer" (Tetsu Kamiya, Meiji Co. Ltd.) 5.8 - In-vitro characterisation of bolus pressure, velocity and internal shear of non-Newtonian gelled liquid in a tongue-palate simulator (Andrew Redfearn, University College London)		
5.30pm	**Journal of Texture Studies announcements re 50 year celebration (Jianshe Chen)**		
5.40pm	**Close**		

7.00 pm - Drinks reception and photograph
7.45 pm - Gala Dinner in the Banqueting Suite, East Midlands Conference Centre – to include award of poster prizes and speech by Chair of FOP Committee

Wednesday July 4th

8.30am	**Rheology and Swallowing of Food**	Mats Stading, Research Institute of Sweden and Chalmers University of Technology	*Chair – Allen Foegeding*
9.00am	**Theme 6 - Impact of Food Oral Processing on health benefits (10 minutes each plus 5 mins questions):**		

9.00-9.15	6.1 - Impact of semolina food structure on mastication and bolus properties – prospects to postprandial glycaemia (Saara Pentikäinen, VTT Technical Research Centre of Finland Ltd.)		
9.15-9.30	6.2 - Variation in chewing behaviour among consumers and its impact on digestion (Esther Kim, The New Zealand Institute for Plant & Food Research Limited)		
9.30-9.45	6.3 - Can oral processing behaviour explain the satiating capacity of yogurts with small texture differences? (Ana Carolina Mosca, Wageningen University, European Sensory Network)		
9.45-10.00	6.4 - Nutrient bioavailability is reduced in elderly with oral deficiency: interest of combining in vitro mastication and digestive approaches (Marie-Agnès Peyron, Université Clermont Auvergne, INRA)		
10.00-10.15	6.5 - Relationship between nutritional sucking habits, taste sensitivity, food consistency and body mass index in children: a multivariate analysis (Paula Midori Castelo, Federal University of São Paulo (UNIFESP, Brazil))		
10.15-10.30	6.6 - Impact of food formulation and processing on saltiness perception (Miroslaw Kasprzak, University of Nottingham)		
10.30am	**Morning Break**		
11.00am	**Interventions for Dysphagia: Modifications of Diet Texture, Head Position and Tongue Strength**	Catriona Steele – Toronto Rehabilitation Institute	*Co-Chairs – Mats Stading and Jianshe Chen*
11.30am	**Theme 7 - Designing Foods for Enhancing Sensory and Consumer Experience – Oral Processing for Specific Consumer Groups (10 minutes each plus 5 mins questions):**		
11.30-11.45	7.1 - Chewing efficiency in 6 to 18 months old children: evolution with age and relationships with food texture acceptance (Carole Tournier, CSGA)		
11.45-12.00	7.2 - A mathematical model of the bolus formation of starch-based foods during oral processing (Muhammad S. How, Riddet Institute, Massey University)		
12.00-12.15	7.3 - Exploring the use of sensory tools to classify commercial dairy products for dysphagia sufferers (Maeva Cochet-Broch, C.S.I.R.O)		
12.15-12.30	7.4 - Exploring temporal methods to assess dynamic product profiles (Louise Hewson, PepsiCo)		
12.30-12.45	7.5 - Parent-reported food texture preferences and texture sensitivity in young children with and without Down syndrome (Charles Ben Bernhard, Washington State University/Sarah Smith-Simpson, Nestle Nutrition)		
12.45-1.00	7.6 - Oral processing behaviour of liquid, semi-solid and solid foods differs between consumers varying in age, gender and ethnicity (Monica Aguayo Mendoza, Wageningen University)		
1.00-1.15	7.7 - Does the portion size matter for the evaluation of sensory perception, hedonic and emotional rates for a regular and a low sugar vanilla ice cream? (Marion Doyennette, Unilever)		
1.15pm	**Conference close**		

Journal of
Texture Studies

Invitation to submit to the Food Oral Processing Conference Special Issue

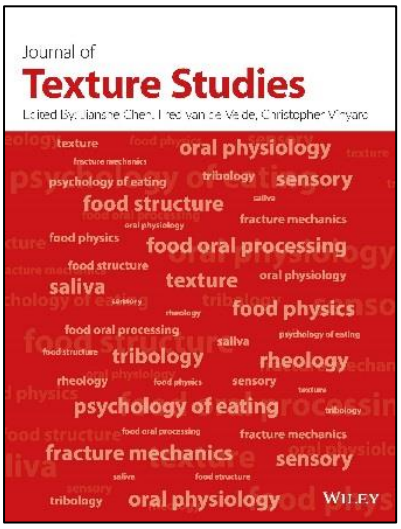
A special issue dedicated to the publication of research originating from the 5th International Conference on Food Oral Processing will by sponsored by the *Journal of Texture Studies*. The Journal invites all oral and poster presenters to submit manuscripts, either as a review, a research article, or a research note by 31st July 2018 for peer review. The issue is expected to be published December 2018.

Submission Guidelines for Authors

The following requirements are mandatory for all conference-related submissions:

- All papers must be submitted electronically via http://mc.manuscriptcentral.com/jts.
- Submissions must be received by the deadline stated above.
- Submissions must follow the Journal's Author Guidelines, which can be found at https://onlinelibrary.wiley.com/page/journal/17454603/homepage/forauthors.html

About the Journal



The *Journal of Texture Studies* is a peer-reviewed international journal historically specialized in the texture and sensory perception of food and other consumer products. The journal was first published in 1969 and has been the primary source for disseminating advances in all sciences related to physical characterization and sensory perception of texture, in particular in areas such as food rheology and microstructure, tactile senses and texture perception, texture features and material attributes (composition, structure, and processing), food oral consumption, and studies associated with eating and sensory appreciation.

Upcoming 50th Anniversary Celebration

In 2019, the *Journal of Texture Studies* will celebrate its 50th Anniversary.

To commemorate this significant milestone in the journal's history, the *Journal of Texture Studies* will organize various special events, including a **50th Anniversary Special Issue**, a virtual issue of the **Top 50 Most Influential JTS Papers**, recognition of **5 Most Outstanding Contributors in Texture Research**, and **10 Rising Stars in Texture Research**.

The journal encourages readers to check the journal website for updates regarding these events, including instructions for submission to the special issue and guidelines for nominations.

Invited Speakers

Presentations

S 1

Progresses and challenges of food oral processing: looking back and forward

Jianshe Chen *(Food Oral Processing Laboratory, School of Food Science and Biotechnology, Zhejiang Gongshang University, Hangzhou, China (Chair of Food Oral Processing Committee))*

The oral consumption of food is a complicated process involving a series of oral actions and coordination, starting from the first bite till after the final swallowing. During this process, food is structurally transformed and a bolus is formed as a mixture of food and saliva. Sensory pleasure is perceived both instantly and in an integrated manner throughout the process. After decades of research efforts, a great understanding has been achieved on the physics and oral physiology of eating and sensory perception. While food rheology has been studied for over a half century as a core physics of food texture, oral tribology emerged in past few years as a new frontier for texture and mouthfeel research. Recently, saliva secretion and food-saliva interactions, on the other hand, are accepted as important oral physiological factors which influence an eating process, both to the dynamics of food structure transformation and to the sensory perception (aroma, taste, as well as texture). This talk will review recent progresses on the physical and oral physiological aspects of food oral consumption. Latest experimental results, both reported in literature and obtained from author's lab, will be discussed. Attempt will also be made in trying to identify new emerging areas of food oral processing research.

S 2

The influence of oral processing on food perception

Andries van der Bilt *(University Medical Center, Utrecht)*

When we chew, the food is broken down by the teeth, while saliva moistens the food and binds the masticated food into a food bolus that can be easily swallowed. Food properties such as structure, composition, appearance, size and shape influence the masticatory function. Hard and dry foods require a relatively large number of chewing cycles before the food is suitable to swallow. More time is needed to fragment the food into small particles and to add enough saliva to the food to form a cohesive bolus that can be swallowed. Chewing a soft food like a banana will lead to different movement patterns of the lower jaw than chewing a crispy food like potato chips. Taste, flavour and texture are perceived during chewing and will contribute to the appreciation of the food. Also, visual information of a food product is essential in the choice and the acceptance of food products. Auditory information obtained during the chewing of crispy products will provide information on whether a product is fresh or stale. Food perception does not just depend on one individual sense but is the result of multisensory integration of unimodal signals. Large differences in oral physiology parameters exist among individuals, which may lead to differences in food perception. Characteristics of the oral system, like number of teeth, jaw muscle activity, bite force, and salivary flow will influence the masticatory process. Neuromuscular control of chewing and swallowing also plays an important role in the masticatory process. Relatively large bite forces must be controlled under uncertain conditions: no optical feedback is available and food resistance may largely vary among chewing cycles. Knowledge of the interplay between mastication and sensory experience for groups of individuals is important for the food industry to control quality and acceptability of their products.

S 3

Oral food processing: a dental perspective

Nikolaos Giannakopoulos *(University Clinic of Wurzburg, Germany)*

Oral food processing is essentially associated with complex kinetic actions controlled by specific neuromuscular interactions of the jaw and neck system. In this context, the development of new food types that address general nutrition needs should consider the masticatory ability and performance which does not represent a stable entity.

Chewing function of the human masticatory system is significantly modified by aging, by painful dysfunctions, or by changes in the dentition. Dentists are challenged by several physiological and biomechanical issues, in their effort to rehabilitate an impaired masticatory system under the aspect of effective oral food processing.

Current progress in FE modelling offers a completely new perspective of prosthodontic rehabilitation in relation to biomechanical performance optimization. The presentation will inform about current experimental studies on food processing and recent developments in kinetic FE modelling, which addresses the short-range interaction of the antagonistic teeth, and in particular, the behavior of the masticatory system during the mincing process of various foods.

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S 4

Improving oral health or changing food texture: the challenge for persons with neuromotor disabilities

Martine Hennequin *(University of Clermont Auvergne, France)*

In people with neuromotor disabilities, swallowing, chewing and dental disease are usually evaluated separately, despite the fact that the development and maturation of these oral conditions are strongly linked. For the general population, it has been shown that dental and general health are related to chewing, that masticatory performance is a prime factor associated with nutritional intake and that poor chewing performance is associated with a preference for the taste and texture of soft foods. Moreover, cranio-facial development depends on muscular activity during mastication, which affects in turn swallowing and respiration. Despite the wide description of orofacial problems, their potential impact on the prevalence of dysphagia in individuals with neuromotor disabilities, we have very little understanding of the evolution and interaction of all these problems within this population. Food refusals and food selection in persons with neuromotor disabilities are often interpretated as resulting from mental deficiencies and behavioural problems rather than physiological ones. Rejection of the taste and texture of hard foods results in a diet that is low in fibre, and high in fatty acids and cholesterol. However, persons with neuromotor disabilities are prone to cardiac disease, gastrointestinal disease symptoms, and malnutrition and the risk of nutritional problems increases and aggravates general health. Evaluation of the oral conditions of persons with neuro motor disabilities are thus of utmost importance and should be examined using a multidisciplinary approach. This presentation will give some keys aiming to improve food oral processing throughout life of persons with neuromotor disabilities.

S 5

From Food Texture to Global Perception: Respective Impacts of Food and Human Physiology

Elisabeth Guichard *(INRA, Paris)*

The acceptability of foods by consumers is mainly driven by its overall perception, including texture, taste and aroma. As food is put in the mouth, food breakdown contributes to the different sensory perceptions until swallowing and the amount of product remaining in the mouth after swallowing contributes to after-feel perception. Food texture depends on food composition and structure but also on oral physiological parameters which vary according to the individuals and impact food bolus structure. Food texture also impacts taste and aroma perception. In fact, a modification of food composition and structure does not only affect texture perception but also aroma and taste perception due to a modification of the release of taste and aroma stimuli. Moreover sensory interactions occur between texture and both taste and aroma sensory perception. The aim of this presentation is to present the effect of food texture on the global sensory perception in dairy products, taking into account food composition (fat, protein, dry matter, ions, texture replacers) and food structure on one hand and human physiological parameters (masticatory behaviour, saliva flow and composition, oral volume, respiratory flow) on the other hand. Examples will be given on semi-hard dairy product which are chewable and for which mastication and salivation play an important role and on different types of dairy emulsions for which tongue-palate compression, melting and saliva composition are more important. Another focus will be done on fat perception, a multimodal perception involving texture, taste and aroma.

S 6

Nuts just take up space where the chocolate ought to be: Food complexity and oral breakdown

Bryony James *(University of Auckland)*

Oral processing, from first bite to the point of swallow, potentially increases, then decreases the structural and textural complexity of a solid food material. This can be seen most dramatically in a dynamic technique such as Temporal Dominance of Sensation (TDS) where consensus about perceived texture appears strong at the start and end of oral processing, and more chaotic in the middle period. Both product-specific and consumer-specific factors influence this trajectory, as fracture dominated properties transition to those dominated by rheology, and chewing action and efficiency alters the breakdown pathway. "Complexity", in this context, has both a structural and a sensory component, and this presentation will cover some of the recent work at the University of Auckland in this area. Structural analysis of chocolate boluses has been challenging and illustrates well the issues faced with isolating product and consumer factors. Also we have shown an impact of complexity on satiation, but still have a long way to go to reveal the mechanisms underpinning the action.

S 7

Individual variation in taste perception: what happens when we thermally stimulate the tongue?

Joanne Hort *(Massey University, New Zealand)*

Consumers vary in their perception of the same in mouth stimulus. We aware of the differences in oral processing behaviours across individuals that affect perception and food choice behaviour but, at the same time, there are an increasing number of taste related genotypes and phenotypes which add to the complexity of understanding consumer response to, and choice of, foods and beverages. In this talk, Professor Hort will review current understanding concerning taste phenotypes and genotypes with a particular focus on thermal taster status. Thermal stimulation of the tongue is known to elicit a taste response in some individuals, between 30-50% of the population. These individuals also report a heightened response to some oral stimuli although the mechanisms behind this are not well understood. Here she will explore consumer response to thermal stimulation of the tongue and its consequences for perception and food choice behaviour.

S 8

Using functional MRI to understand individual variations in taste perception

Sue Francis *(University of Nottingham)*

The perception of taste is known to vary widely across individuals. There are many factors that contribute to an individual's taste perception and subsequent food preferences which may in turn impact health status. This presentation will begin with a brief outline of the use of functional MRI (fMRI) to study brain function. This will be followed by an outline of the use of fMRI as a method to explore the brain's cortical activity to taste perception, and improve the understanding of the neural effects of taste phenotype, specifically PROP and thermal taster status (TTS).

The presence of fat alters the taste, aroma and textural attributes of food products and these attributes, together with fat's high energy density, make high fat food products very rewarding to the consumer. The brain's response to iso-viscous, iso-sweet fat emulsions of increasing fat concentration will be presented, and the correlation of behavioural and neuroimaging responses to fat emulsions with PROP taster status will be shown, highlighting the finding of a strong correlation of the fMRI response in somatosensory areas with PROP taster status. A study of how the cortical response of fat emulsions is influenced by prior gastrointestinal exposure to the same emulsion is described to assess effects of satiety and habituation.

Functional magnetic resonance imaging (fMRI) provides a method to reveal the network of brain areas involved in taste perception. Results of using ultra-high-field (7 Tesla) fMRI to investigate how tastes (sweet, bitter, salty, sour, umami, metallic) are mapped in the human primary taste cortex at very high spatial resolution will be show and how this relates to PROP phenotype.

Finally, using fMRI we address the question of whether phantom taste is a central processing phenomenon. We report the results of a study to scan the brains' of thermal tasters whilst their tongue is rapidly cooled or warmed. This unique study demonstrates that the phantom taste sensation modulates the same area of the primary taste cortex as a real taste.

Overall, this presentation aims to advance understanding of human taste perception and individual taste variability using fMRI methods.

S 9

Oral Processing and Its Impact on Metabolic Outcomes

Jeyakumar Henry *(Clinical Nutrition Research Centre, National University of Singapore)*

Food ingestion is a daily activity that starts at birth. The earliest research on oral food processing concentrated on the physics of food breakdown including the mechanical properties of bolus formation and the process of lubrication offered by saliva. The association between diet and health has stimulated a resurgence of interest in understanding how oral food processing may influence health and nutrition. During the past few years, we have witnessed a large expansion in our understanding of the physico-chemical properties of food and their metabolic consequences. A considerable opportunity now exists in understanding how food structure can be manipulated to design and formulate novel foods. These novel systems can then be used to alter the bioavailability (increase or decrease) depending on the macro-micro nutrient under consideration. The nexus between food structure, oral processing and nutrition is an emerging field that has significant opportunities but large gaps in our knowledge still exists. This presentation will be a stimulus to enhance our understanding of this association. It is now well recognized that oral food processing is a major factor in the perception of flavour, taste, and texture and food preference. Once food is placed in the mouth, it is subjected to a series of complex processes that involve the teeth, tongue, cheek, saliva and the muscles that surround the mouth. In this presentation, a series of studies will be presented to illustrate how food structure, particle size, gel formation, food structure manipulation and mastication, can all be used to enhance the health benefits of the foods we consume. Examples include how food structure and mastication may impact on glycaemic response, energy intake, and lipid metabolism. Hardness of food has been shown to effect eating rate. The recent observation that basal metabolic rate may be a factor that influences eating rate, opens up a series of innovative ideas that may be used to manipulate glycaemic response, eating rate and energy intake. The presentation will further illustrate how this disruptive science may be used to develop novel foods with unique nutritional properties with special focus on diabetes and obesity.

S 10

Rheology and Swallowing of Foods

Mats Stading *(Research Institute of Sweden and Chalmers University of Technology)*

Healthy individuals apply highly unconscious, but well-coordinated strategies for the oral processing producing easy-to-swallow boluses. We prepare a bolus by chewing and mixing with saliva and as soon as we initiate swallowing, it is an involuntary process. However, for an increasing proportion of the population the actual swallowing causes problems. Swallowing disorders, or dysphagia, affects 40% of the ones older than 70 due to dementia, trauma or medication side effects. The swallowing disorders may cause the food to enter into the airways which causes anything ranging from coughing to pneumonia or even choking. Swallowing disorders also lead to malnutrition which in turn leads to weight loss, frailty and finally to nursing homes, hospitalization, disabilities or even death. It is therefore critically important to formulate foods which have suitable rheology for easy oral processing as well as for safe swallowing.

The effect of rheology on swallowing and food oral processing will be exemplified by three cases. Firstly, fluid thickening is a well-established management strategy for dysphagia. Fluid foods are thickened with hydrocolloids which provide increased viscosity, as determined by the shear viscosity at 50 1/s. However, the effects of thickening on impaired swallowing are not fully understood and the relations to basic rheology are scarce.

Fluid elasticity has been found beneficial for safe swallowing due to the assumed induced cohesiveness of the bolus, i.e. the bolus passes the throat without breaking up and without droplets entering the airways. Three food grade model fluids were therefore created to evaluate this effect: a Newtonian fluid with constant shear viscosity, a Boger fluid with equal shear viscosity as the Newtonian but with an elastic component, and a shear thinning 3 / 3 fluid also with an elastic component. These fluids were evaluated by sensory panels, patients with swallowing disorders and analytically by rheology and x-ray videoflouroscopy during swallowing. Fluid elasticity was found to be beneficial for safe swallowing, and the effect was also confirmed by the patients.

The Gothenburg Throat is an in vitro model of the upper part of the throat, the pharynx, designed to elucidate the effect of bolus rheology on swallowing and to simulate different types of disorders. A bolus is injected at controlled volume and speed, and the pressure at four different places is monitored together with the velocity profile during the passage through the pharynx. The closing of the epiglottis covering the airways, the closing of the vocal cords as well as the nasopharynx and upper esophageal sphincter is controlled to mimic healthy as well as malfunctioning swallowing.

In another project magnetic nanoparticles are utilized to non-invasively monitor changes in rheology during food oral processing. The rotation of the particles gives the surrounding nano-rheology without disturbing the actual food oral processing.

S 11

Interventions for Dysphagia: Modifications of Diet Texture, Head Position and Tongue Strength

Catriona Steele *(Toronto Rehabilitation Institute)*

Oropharyngeal dysphagia (swallowing impairment) is a serious medical condition, involving two concerns: 1, the inability to swallow safely, whereby material enters the airway ("penetration-aspiration"); and/or 2, the inability to swallow efficiently, with residue remaining in the pharynx. Among the most commonly used clinical interventions for dysphagia are diet texture modification, the use of altered head positions (such as the chin-down maneuver) and exercise-based treatment to improve tongue strength.

In this talk, Dr. Steele will discuss what is known about healthy swallowing physiology across a range of different bolus consistencies. Recent data incorporating videofluoroscopy in combination with simultaneous measurement of tongue pressures will be shared. The impact of rheological characteristics such as shear viscosity, gravity flow and yield stress on bolus flow through different regions of the oropharynx will be explored.

The evidence regarding treatment techniques involving altered head positioning and improved tongue strength for improving swallowing function in people with dysphagia will be reviewed. In closing, the potential interaction of head positioning, tongue strength and bolus texture modification for influencing safe and efficient propulsion of liquids ranging from thin to extremely thick consistencies through the oropharynx will be explored.

Themes:

1 & 2

Oral Physiology and Dentistry

Oral Presentations

1.1

Inclusion of the initial phase of mastication for determining chewing efficiency using a solid test food

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Chewing ability has been examined using the solid artificial test food Optosil®. The median particle size, X50, is determined after N chewing cycles, by curve-fitting of the particle size distribution using the Rosin-Rammler equation. Reduction of X50 with N is traditionally studied from N ≥ 15-20 cycles, because of initially unreliable values of X50. The first aim of the study was to show that the initial chewing phase can be considered by using initial particles of appropriate size, shape and amount. The initial phase is important because (1) greatest reduction in X50 occurs here, and (2) it includes a transition from a slower to faster reduction rate. The second aim was to compare measures of chewing ability, i.e. chewing efficiency (N needed to halve the initial particle size, N(1/2-Xo)) and chewing performance (X50 at a particular N-value, X50,N).

Eight young adults chewed 4 types of samples of particles: (1) 8 cubes of 8 mm, border size relative to bin size (traditional test), (2) 9 half-cubes of 9.6 mm, mid-size; similar sample volume, (3) 4 half-cubes of 9.6 mm, and 2 half-cubes of 9.6 mm; reduced particle number and sample volume. All samples were tested with 4 N-values. Curve-fitting with a 2nd order polynomial function yielded log(X50)-log(N) relationships, after which N(1/2-Xo) and X50,N were obtained.

Reliable X50-values are obtained for all N-values when using half-cubes with a mid-size relative to bin sizes. By using samples of 2 half-cubes, determination of N(1/2-Xo) or X50,N needs fewer chewing cycles and 40% less bite force than traditional tests, making a chewing test feasible for subjects with an impaired chewing ability. Chewing efficiency is preferable over chewing performance because of a comparison of inter-subject chewing ability at the same stage of food comminution, and constant intra-subject ratios between samples and constant inter-subject ratios within samples.

1.2

Oral Peri-Receptor Events Affecting Salt Taste Sensitivity

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Although dietary salt intake is essential for vertebrates in the homeostatic regulation of water balance, osmotic pressure and nerve conductance, excess of sodium chloride (NaCl) intake has been correlated to cardiovascular and renal diseases. To efficiently develop low sodium foods without compromising on salt taste quality, the present study investigated inter-individual salt taste sensitivity in context with oral mechanisms involved in salivary peri-receptor events and sodium-induced ion pharmacology. 35 Healthy panellists were screened in their full detection functions for NaCl and classified according to their sensitivity. Highly sensitive (S+) and non-sensitive panellists (S-) were challenged with a series of salt stimuli and saliva collected. Time-dependent changes in the salivary proteome were then analysed by tryptic in-solution digestion, iTRAQ labelling and nano-LC-MS/MS. Dynamics upon stimulation and differential proteome pattern between sensitivity groups seemed to be two largely independent conditions. Sensitivity relied on subjects' initial salivary conditions whereas a tastant stimulation triggered the release of antimicrobial proteins. Marker proteins indicative of the S+ and S- groups demonstrated a highly significant enrichment in contrasting biological functions, e.g. the S+ group exhibited significant enrichment in endopeptidase activity whereas S- subjects showed high abundance in proteins with endopeptidase inhibitor activity. To further investigate the inter-individual variability in NaCl sensitivity, 20 volunteers were sensorially classified, saliva samples collected and analysed using targeted protein quantitation. The joint abundance of lipocalin-1 and lysozyme C was found to be highly indicative for a decreased NaCl sensitivity. At the same time, a serine-type endopeptidase was shown for the first time to exhibit a salt enhancing effect which could further be assigned to an in-vivo release of salt-modulating peptides through digestive salivary processes.

1.3

Which variables should be controlled when measuring the granulometry of a chewed bolus? Results from a quantitative synthesis.

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The distribution of food particles in a chewed bolus is frequently used as a criterion to characterize the outcome of mastication. Previous literature reviews stated that methodological differences in the characterization of bolus granulometry do not allow inter-study comparisons. The aim of this systematic review is to: i) identify the variables that can affect bolus granulometry, and ii) calculate the relative weight of these variables in bolus granulometry variations. The qualitative review reports that bolus granulometry values varied according to the conceptual approaches employed, i.e. chewing-test or mastication-test, measurement methods, and the food or material proposed for chewing. Based on 58 studies, the quantitative analysis shows that when food, number of chewing strokes, and the oral status of the subjects are controlled, the values obtained can be used as references in further nutritional studies. This review provides tables that could be useful for further research either to identify studies conducted with specific experimental procedures, or to refer to bolus granulometry values for foods and subjects.

1.4

Impact of oral health on masticatory efficiency and kinematics in young children

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The preschool period is critical for the physiological maturation of the orofacial sphere. Oral health is considered as an influencing factor of the development of mastication, which is the first step of food consumption. However, while the impact of early dental decay on children's nutritional and weight and height states has often been evoked, few studies have assessed mastication in young children, regardless of their oral state. This work aimed at analyzing the masticatory behavior and efficiency in children with Severe Early Childhood Caries (S-ECC) compared to children with good oral health.

Thirteen children with S-ECC and 13 children from the control group were compared while masticating calibrated samples of raw carrot, cheese and breakfast cereals. The chewing evaluation criteria included refusals rates, kinematic parameters observed during a masticatory sequence (chewing time before swallowing (Ti), number of cycles (Nc) and frequency: Nc/Ti) and masticatory efficiency (D50 value: food bolus median particle size). Oral health-related study criteria were the number of Functional Dental Units, Oral Health-related Quality of Life scores (Early Childhood Oral Health Impact Scale: ECOHIS) and orofacial dysfunction scores (Nordic Oro-facial Test-Screening questionnaire: NOT-S). The chewing frequency was significantly lower in the S-ECC group compared to the control group, regardless of the food ($p \leq 0.001$). Masticatory efficiency was also significantly altered in children with S-ECC, who swallowed a food bolus containing a greater proportion of large particles (i.e. carrot D50 (µm): 4384 ± 929 for children with ECC vs. 2960 ± 627 for children from the control group, $p \leq 0.001$). Quality of life and orofacial functions were also altered by S-ECC.

In conclusion, this study has shown for the first time the negative impact of oral health on the masticatory behavior and efficiency in preschool children, suggesting that nutritional studies conducted during children development should take into consideration their oral state.

2.1

Exposure to chocolate almond milk likely increases human salivary expression of proline rich proteins

Ciera Crawford *(Purdue University), Cordelia Running (Purdue University)*

Salivary proline rich proteins (PRP) bind polyphenols, which can influence the sensation of astringency. However, the extent to which repeated exposure to polyphenols causes a change in salivary protein expression in humans in unknown. Studying this relationship is further complicated by proteins in foods that are functional analogs for salivary proteins, such as gelatin and bovine milk caseins, which mimic the activity of salivary PRP toward polyphenols. In this study, we tested whether exposure to chocolate milk would change salivary protein expression, and whether the type of milk would influence those changes. To do this, we added cocoa (2.5%) to almond and bovine milks, and also made another cocoa almond milk with gelatin (0.2%). Milks were provided to subjects in a 6-week study. In alternating weeks, subjects avoided high polyphenol foods for one week then drank one of each chocolate milk the next week. After each week, saliva and sensory ratings for the three milks were collected. Subjects also provided expectorates of each milk. Changes in sensory ratings and salivary proteomes from beginning to end of each intervention week were evaluated. Expectorated milk samples were analyzed to determine if binding of polyphenols differed across milk types and individual salivary profiles.

Preliminary proteomic analysis indicates higher concentrations of salivary PRP after exposure to chocolate almond milk, along with increases in two mucins, several potential immune related proteins, and carbonic anhydrase 6 (data pending for other milks). Analysis of expectorated milks indicates variability for binding and quantity of recovered polyphenols based on milk type; these data will be compared to salivary proteomes when the dataset is complete. The preliminary analysis, however, indicates that exposure to polyphenols alters expression of salivary proteins that may in turn influence sensory perception of the polyphenols.

2.2

Unravelling the effects of interindividual variability of human saliva on aroma compounds

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In the last 20 years a lot of research has been devoted to understanding the intra-oral release of aroma compounds, and particularly, about the role of saliva on this process1. During eating, aroma compounds are released from the food matrix and dissolved in saliva, where they can be submitted to different effects (e.g. retention, salting-out, metabolization). These effects might determine the rate of aroma compounds available to reach the olfactory receptors. In spite of the well-known variability of salivary parameters (flow and composition) among individuals, its effects on aroma compounds have been poorly studied (in particular in specific populations, such as elderlies). Therefore the main objective of this work has been to elucidate the role of human saliva on aroma compounds taking into account interindividual variability.

For this purpose, in vivo aroma release was monitored using PTR-ToF-MS in elderlies (n=73; mean age=74,0 y/o), who were asked to drink an aromatic solution. Aroma release data were submitted to multiple regression analyses in order to relate individual physiological and salivary parameters with aroma release over time. Results showed that interindividual differences on aroma release were mostly correlated with salivary composition parameters (positively with total protein content and negatively with total antioxidant capacity) and with the body mass index of the individuals (negatively). Additionally, differences among aroma compounds were observed. Some compounds (linalool, 2-pentanone, 2-nonanone) were more persistent in the breath than others (2,3-hexanedione, octanal). Ex vivo experiments allowed to ascertain that metabolites were formed from the less persistent compounds after their incubation with saliva, which suggests a role of metabolization by saliva of specific aroma compounds. These results show the importance of considering interindividual differences in human saliva composition to gain a deeper understanding on food aroma perception. 1.Ployon, Morzel & Canon. (2017). Food Chem., 226;212-220.

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2.3

Responses of the Salivary Proteome to Transient Receptor Potential Channel Agonists

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Transient Receptor Potential (TRP) channel agonists have been shown to increase salivary flow rate and modify the physical properties of saliva but there are no studies investigating their effects on the salivary proteome. The aim of this study was to investigate how the whole mouth saliva (WMS) proteome is affected by the TRP channel agonists; nonivamide (TRPV1 agonist, capsaicin analogue), menthol (TRPM8 agonist) and cinnamaldehyde (TRPA1 agonist).

WMS was collected after mouth-rinsing with water, nonivamide, cinnamaldehyde and propylene glycol (vehicle) at concentrations just above their detection thresholds (determined by the 3-AFC method). The proteomes of collected WMS were analysed by relative-quantitative LC-MS/MS. In a follow up study, nonivamide, cinnamaldehyde, propylene glycol and menthol were used at concentrations previously determined to be strong sensory stimuli. WMS was collected before and for two minutes after mouth-rinsing with water and each compound. The proteomes of collected WMS were analysed by TMT-labelled absolute-quantitative LC-MS/MS. Following mild stimulation, 36 of 1026 identified proteins showed a significant fold-change from the post-water sample. Clustering analysis determined that variation was participant rather than stimulus dependent.

Following stronger stimulation, 522 proteins were identified and clustering determined that proteome changes were more mouth-rinse dependent. Protein fold-changes reflected altered biological process and function of the proteome in a gene ontology analysis. Nonivamide and menthol mouth-rinses increased submandibular gland associated proteins whilst cinnamaldehyde increased parotid gland associated proteins.

We demonstrate that the WMS proteome varies in its response to TRP channel agonists. When the stimuli are at the detection threshold, most of the variation is seen between individuals but more strongly stimulating concentrations cause compound specific changes. These compositional changes reflect biological process and function as well as differences in how the major glands contribute to the stimulated WMS proteome giving insight into the mechanism responsible for the differing responses.

2.4

Discrimination of chocolate texture varies with individual differences in oral somatosensation

John E Hayes *(Penn State), Scott P Breen (Penn State)*

Texture plays a major role in the acceptance or rejection of many foods. In chocolate, grittiness/sandiness is driven by sugar crystal size. Industrial lore suggests chocolate is gritty or sandy if particle sizes at the 90th percentile (D90) exceed ~25-35 microns, although data behind this dogma is unclear. In experiment 1, we measured just noticeable differences (jnds) for experimental chocolate in the range of 19 to 32 microns, and analyzed 9 commercially available dark chocolates on the market in the US and Europe to determine particle sizes. In 60 adults, jnds were ~4.7 microns. Most (8/9) commercial chocolates had D90 particle sizes of 19.2-25.2 microns. While mechanisms of oral texture perception remain poorly understood, Linne and Simons recently reported differences in roughness discrimination are related to the astringency of epigallocatechin gallate. Thus, we explored whether individual differences were related to particle size perception in chocolate. In experiment 2, we assessed two oral touch measures, oral point pressure sensitivity and surface roughness discrimination, testing whether either one would predict differences in chocolate texture. In 51 adults, pressure point sensitivity thresholds were measured with Von Frey Hair (VFH) monofilaments (8mg-10g) and surface roughness thresholds were measured with stainless steel blanks ground to different roughness (0.54-0.72 microns), both using staircase procedures. Two commercial dark chocolates differing in particle size (19 v. 26 micron) were evaluated for grittiness via a 2AFC task. Point pressure sensitivity and roughness discrimination were variable, so we separated participants into groups for roughness (RLow v. RHigh) and point pressure sensitivity (PPLow v. PPHigh). Overall, participants successfully discriminated between the two chocolates, but this was driven almost entirely by those more sensitive to VFH pressure: 85% of the PPLow group correctly identified the grittier chocolate, versus chance performance (50%) for PPHigh. No effect was seen for the two roughness groups.

2.5

Linking oral processing behaviour to oral physiology of consumers varying in age, gender and ethnicity

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Food oral processing behaviour is known to be affected by age, gender and ethnicity. Changes in oral physiology occur during ageing and might affect oral processing behaviour. Differences in food oral processing behaviour between consumers of different ethnicities and consumers of different gender may also be explained by differences in oral physiology and psychological factors during food consumption. At this moment, there is no study which has studied the link between oral physiology and oral processing behaviour of different consumer groups. The aim of this study was to link oral physiology of consumers varying in age, gender and ethnicity to their oral processing behaviour. To characterize the oral physiology of consumers varying in age, gender and ethnicity, 3 groups consisting of healthy consumers , Dutch Caucasian adults (18-30 years, n=36), Chinese Asian adults (18-30 years, n=36) and Dutch Caucasian elderly (65-85 years, n=36) were recruited. Oral physiology of all consumers was characterized by salivary flow rate (both rested and stimulated saliva), volume of oral cavity, mastication efficiency (as the particle size and number of particles of a masticated artificial rubber), tongue dimensions and dental status. The oral processing behaviour was assessed by video recording the consumption behaviour of the subjects, while consuming a carrot, cheese and sausage sample. From the video recordings 4 oral processing parameters were extracted: consumption time, bite size, eating rate and number of chews. Additionally, 5 food-related questionnaires were used to assess food intake, food choice, contextual factors and health aspects during food consumption and texture preferences. Data collection is ongoing. The data analysis will link the oral physiology with the oral processing behaviour of the different consumers. With the current study we hope to gain a better understanding of the link between oral physiology and oral processing behaviour among different consumer groups will be obtained.

Theme:

3 Food Texture During Consumption

Oral Presentations

3.1

Toppings facilitate oral processing behavior of bread and crackers

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Many foods that are frequently consumed consist of multiple food components, for example bread with toppings such as cheeses or mayonnaises. Such foods are referred to as composite foods. The individual components of composite foods can differ considerably in composition, mechanical properties and sensory characteristics. During oral processing the components are broken down differently and mixed together in the mouth to form a bolus. Limited knowledge is available about the oral processing behavior and sensory perception of composite foods. The aim of this study was to investigate the effect of different toppings on oral processing behavior and dynamic sensory perception of carrier foods when consumed as composite foods. Two carriers (bread and cracker) and three toppings (semi-hard cheese, cheese spread and mayonnaise) were used and six carrier-topping combinations were prepared. Mastication behavior (chewing duration, number of chews, chewing frequency), bolus properties throughout mastication (moisture content, saliva incorporation, mechanical properties) and dynamic sensory perception (progressive profiling of 4 attributes) were determined for the individual carriers and the six carrier-topping combinations. Carriers with soft toppings (cheese spread and mayonnaise) were chewed for a significantly shorter duration and with fewer chews than the individual carriers bread and crackers although twice the mass of food was orally processed. These toppings contributed to a faster bolus formation by providing moisture to the bolus, and therefore less saliva was incorporated into the bolus. As a result of the moisture incorporation, carriers with soft toppings were perceived less firm than carriers without toppings. In addition, all three toppings decreased the dryness perception of carriers at any moment during oral processing. We conclude that both the properties of carriers and toppings impacted oral processing behavior and dynamic sensory perception of composite foods. Carriers dominated the oral processing behavior rather than the toppings.

3.2

Temporal aspects of cream cheese texture perception using Temporal Dominance of Sensations (TDS) tool

Dian Widya Ningtyas *(The University of Queensland), Bhesh Bhandari (The University of Queensland), Nidhi Bansal (The University of Queensland), Sangeeta Prakash (The University of Queensland)*

Temporal Dominance of Sensations (TDS) is a sensory descriptive tool that provides information about the sequence of the dominant attributes in a product when processed in the oral cavity and their subsequent changes over time. In humans, texture perception of any food is a dynamic process that plays a major role in acceptance of the food. The TDS tool allows understanding the dynamic textural sensation in the mouth. In this work, this tool was applied to study the creaminess, smoothness, cohesiveness, thickness and mouthfeel of cream cheese added with β-glucan and phytosterol (esterified and native). A trained sensory panel perceived the dynamic textural sensations introduced by cream cheese with and without these functional ingredients. The TDS data obtained showed that the first dominant attribute depends on the ingredient that make-up the cream cheese. The textural attributes of cohesiveness, thickness and smoothness were the first dominant attributes while mouth coating significantly dominated at the end of mastication for all cream cheese added with functional ingredients. However, in reduced fat cream cheese without functional ingredients mouth coating was the only significant dominant attribute (dominance rate of 40%) throughout the oral processing. The TDS results complemented the instrumental characterisation of the cream cheese where the addition of these ingredients significantly increased the firmness (from 0.85 to 1.99 N) and made them less spreadable (from 6.6 to 14.8 N/s). Rheology/tribology data also related well with the thickness/creaminess sensations. The use of phytosterol in native form tended to increase the viscosity of cream cheese, while the esterified form contributed to the lubrication properties similar to fat, lowering the coefficient of friction. The TDS profile of high-fat cream cheese, characterised by the highest dominance rate (70%) of creaminess also represented the least coefficient of friction.

3.3

From first to last bite: Emotions change from high to low arousal and dominant sensations built-up during multiple bite assessment of yogurt

Roelien van Bommel *(Wageningen University), Markus Stieger (Wageningen University), Nicole Boelee (Wageningen University), Pascal Schlich (INRA), Gerry Jager (Wageningen University)*

Sensory perceptions and food-evoked emotions evolve over time. Evaluation of sensory perceptions and food-evoked emotions after one bite are common. However, single bite assessments do not represent normal eating behaviour as consumers eat food portions with multiple bites. We hypothesise that dynamics of sensations and emotions not only evolve within a bite but also evolve between bites. This study aims to investigate the temporal dynamics of sensations, emotions and hedonic perceptions using multiple bite assessment employing Temporal Dominance of Sensations (TDS), Emotions (TDE) and alternated Temporal Drivers of Liking (A-TDL). Seventy-six participants evaluated six yogurts with granola pieces varying in size, hardness and concentration. Results showed that sensations were mainly dominated by yogurt attributes in the beginning of each bite (creamy and sour), whereas at the end of each bite sensations were dominated by granola attributes (sweet, wheat and sticky). Sticky sensations gradually increased in dominance duration from the first to the last bite. Creamy, crunchy and sweet were observed to be positive drivers of liking, consequently increasing liking. Sour and sticky were negative drivers of liking, decreasing liking upon dominance of these attributes. All yogurts were characterised by a dominance of interested feelings at the beginning of the first bite. However, the dominance of interested disappeared and dominance rates of bored feelings increased towards the last bite. We conclude that specific texture attributes built-up in dominance perception from the first to the last bite, and food-evoked emotions shift from high (e.g. interested) to low (e.g. bored) arousal emotions from the first to the last bite. These findings indicate that multiple bite evaluations of dynamic sensations and emotions provide additional information about food perception, such as the built-up of sensations from bite to bite. These changes in sensations and emotions cannot be quantified by single bite assessments.

3.4

On relating rheology and oral tribology to sensory properties in hydrogels

Emma Krop *(University of Leeds), Marion Hetherington (University of Leeds), Melvin Holmes (University of Leeds), Sophie Miquel (Mars-Wrigley), Anwesha Sarkar (University of Leeds)*

Understanding the characteristics of oral processing (chewing, lubrication) has drawn significant research attention with the focal point recently shifting from rheology to tribology. The aim of this study was to understand the relationship between the material properties (rheology, tribology) and the sensorially perceived textural attributes (quantitative descriptive analysis, QDA®) using semi-solid model foods i.e. biopolymeric hydrogels. Fracture properties and flow curves of κ-carrageenan hydrogels (κC) and mixed hydrogels containing different ratios of κC and locust bean gum (LBG), sodium alginate (NaA) or with inhomogeneity by introducing 300 or 1000 μm calcium alginate beads (CaA) at 1-4 wt% total biopolymer concentration, were evaluated. Friction coefficient (μ) of the hydrogel-boli after simulated oral processing were compared when sheared between polydimethylsiloxane (PDMS) ball/disc tribopairs with pre-adsorbed artificial salivary film at 37 °C. Nine sensory attributes were identified with a trained sensory panel (n=11) that could be related to either the chewing or lubrication related aspects of oral processing. Our results demonstrated that fracture properties were directly correlated to the chewing-related QDA attributes, such as firmness, elasticity and chewiness, as well as inversely correlated to the lubrication-related attributes pastiness and melting ($p < 0.05$). On the other hand, μ at orally relevant speeds (3-50 mm/s) was inversely correlated to pastiness for the gel bolus fluid where the large bolus fragments were filtered out. In spite of having 'ball-bearing'-mediated lubrication aspects in samples containing CaA beads, they did not show significant sensory 'smoothness' owing to their particle size exceeding the sensory threshold. Thus, our study demonstrated a unique relationship between rheology, tribology and sensory perception in aqueous hydrogels, which can open new horizons in designing new foods with tailored orally perceived textural attributes.

3.5

Evolution of bolus granulometry and bioaccessibility of proteins during mastication of chopped and non-chopped beef meat

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Micronutrients deficiencies (MNDs) affect 30% of the world population, the majority of which is due to iron deficiency. Another health concern, affecting especially old people, is sarcopenia. The latter and MNDs are due to or worsened with malnutrition and are treated by intakes of the required nutrients. Eating meat is the simplest way to insure these intakes, as red meat contains vitamins, proteins and heme iron. People with impaired mastication often reduce their meat consumption or swallow large particles, because of their difficulty to chew such food. Consequently, they lower their iron, proteins and vitamins intakes, increasing the risk of sarcopenia or anemia. Swallowing large particles may also reduce the nutrients bioavailability, although it is not yet established. This work aimed at studying the release of bioaccessible proteins of chopped and non-chopped beef meat during in vitro mastication supplemented with human saliva, using the AM2 masticator.

The AM2 masticator was set up with the physiological parameters of healthy human mastication. For both meat products, the mastication was stopped at 20, 50 and 100% of its progression. Three repetitions were made for each step, and the bolus granulometry (D50 value) and the proteins global concentrations were assessed.

The granulometry of both meat textures boli decreased as mastication progressed. The proteins concentration increased in the non-chopped meat boli. However, it remained constant in the chopped meat boli to a level corresponding to that of a non-chopped meat boli at 99% of mastication progression. This study suggested that chopping meat for people with impaired mastication could compensate for global protein release. However, further studies are needed to evaluate the impact of the difference in the kinetic release from both meat textures on proteins bioavailability. This work was supported by the French AlimaSSenS project (ANR-14-CE20-0003).

3.6

Carbonation as a novel taste-free thickener increases swallowing time

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INTRODUCTION: Dysphagia remains a common problem which is difficult to manage. Food/liquid physical characteristics can be altered by thickeners which aid swallowing by recruiting the tongue into the swallowing process. One drawback of thickeners is that they often impart a taste and mouthfeel. Here, we compare a thickened liquid using a conventional food thickener with carbonated water and then in combination. When combined the thickener retains the carbon dioxide bubbles into the matrix forming an even thicker liquid which still flows.

METHODS: Healthy volunteers aged 18 or older (n=10) were studied on a single occasion. Using a partially inflated balloon attached to a manometer, tongue pressure was measured before being asked to drink 100ml of 4 different solutions in a random order – still and carbonated water with and without thickening powder. All 4 were prepared with orange concentrate to standardise the taste. Time and number of swallows was recorded as well as asking participants to complete a VAS for each drink on ease of swallowing.

RESULTS: We found a strong link between adding thickening powder and increasing both swallowing time and number of swallows. Carbonation, without thickener, had no statistically significant difference from still water. However, interestingly, carbonation with thickening powder took significantly more time and number of swallows to drink than when thickening powder was mixed with still water. Tongue pressure showed a weak positive correlation with increased time to swallow. Similarly, the VAS reflected the swallowing times of thickened fluids.

DISCUSSION: All subjects found thickened fluids more difficult to swallow. Thickness was increased by the incorporation of bubbles which provide an easier way to thicken liquids than thickeners. This has implications for dysphagia management in the acute phase and could also guide future research into improving long-term adherence to treatments by altering the physical characteristics of a substance.

3.7

Modifying gluten-free bread structure by different baking conditions: impact on oral processing and sensory perception

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Gluten plays a key role in the structure of breads, responsible for their particular characteristics during consumption. It is usual to modify the composition of gluten-free breads for modulating the structure, but other aspects like the processing should be taken into account. The aim of this study was to evaluate how the changes in the structure of gluten-free breads derived from different baking conditions affect oral activity, properties of the bolus and sensory profile. On this basis, four types of bread were prepared maintaining the same composition and modifying the amount of water and the time of fermentation. The behaviour of breads in mouth was studied by different parameters such as oral activity, fragmentation pattern (particle characterization of bolus after 3 chewing cycles) and bolus characteristics at swallowing (moisture content, consistency and adhesiveness). Perceived sensations during consumption were assessed using TDS technique. Results showed that oral activity, bolus properties and sensations perceived during eating breads were mainly affected by the differences in structure due to the fermentation duration. Long fermentation breads resulted in a shorter and easier oral processing, requiring less chews and swallows in the case of long fermentation. The fragmentation pattern of these breads was also different: they broke down in more particles of smaller and homogeneous size. Breads with lower initial moisture need higher incorporation of saliva for reaching similar water content at swallowing which suggests that a certain moisture level is needed for triggering swallowing. Boli at swallowing were also different in consistency: they were softer and less adhesive with long fermentation. Regarding sensory perception, TDS curves showed different perceptions according to the duration of fermentation. The overall results showed that the structure of gluten-free breads can be modified to tailor its processing behaviour, mechanical features and sensory properties by only varying baking conditions.

3.8

Temporal Dominance of Motions: a new concept to enlighten the links between texture perceptions and oral processing

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Texture perception is a multidimensional and dynamic phenomenon. Consumers adapt their oral strategy to the bolus properties throughout sequences of motions that depend (i) on the degree of breakdown required by food, but also (ii) on individual preferences in terms of in-mouth behavior.

However, the links between motions and texture perceptions during oral processing still remain only partially identified. Understanding these links is critical to better account for the physiological characteristics of consumers in the design of foods, in particular for specific populations (infants, elderly, or patients with dysphagia). For this purpose, a method entitled "Temporal Dominance of Motions" (TDM) was developed. Drawn from "Temporal Dominance of Sensations" (TDS), TDM is based on the real-time description of the sequences of in-mouth motions and elementary physiological actions during oral processing. 16 trained panelists were asked to describe 12 food gels (including commercial and laboratory samples) with the use of TDM, TDS, and sequential sensory profiling methods. The data were then analysed to identify the main oral actions at the origin of the texture perceptions of these gels.

The results report a wide variety of TDM and TDS patterns throughout the different gels. In spite of an important diversity of oral behaviors reported among the panelists, different steps of consensus have also been identified between in-mouth actions and texture perceptions. At early stage of oral processing, depending on the mechanical properties of the gels, tongue or molar actions are involved, leading respectively to the evaluation of firmness or moistness, or to friability or brittleness. Just before swallowing, sticky and grainy boli were shown to require more frequently the use of tongue and cheeks, as well as the incorporation of saliva.

This study demonstrates the potential interest of this newly built TDM methodology as an original tool to better understand the different dynamic mechanisms involved in texture perceptions.

3.9

Texture-dependent mastication behaviors of the elderly with a different dental status

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Masticatory characteristics of the differently textured food(jelly-type and radish Kimchi) in the elderly group(32 female participants, 65-85 yrs) were collected using by electromyography(EMG). Mastication parameters such as chewing time, number of chewing, magnitude of each chew and the chewing patterns were analysed with age- and denture-dependency. Further, tongue pressure was recorded using by IOPI equipment, and then the magnitudes of tongue pressure were compared under the dental status. Results show that chewing number and chewing time increased depends on the hardness of the samples. However, the slope of linearlity in hardness is dependent on the intrinsic food structure, indicating impacts of food structural and textural characteristics on the chewing properties. In addition, the muscles both masseter and temporalis were not activated on jelly sample at any level of hardness, but significantly activated on radish Kimchi, showing that hard-type radish Kimchi can be texturally modified and served to the elderly with different dental status. The chewing patterns in EMG burst duration, peak shape, chewing rhythm and on-set latency during mastication of the jelly and radish Kimchi are different between the natural teeth and denture wearers. Tongue pressure also depends on both the age and the dental condition and especially the whole denturers have much lower tongue power than the others.

Theme:

4 Food Physics During Consumption

Oral Presentations

4.1

Chewing behavior of high-protein expanded pea flour

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Legume-based protein foods can overcome the challenges of protein transition and sustainable agriculture. Extrusion is a convenient process to fabricate such a food. Due to the reactivity of the protein components, extrusion produce foams with various texture and composite morphologies, which govern extrudates chewing performance. At an onset extrusion temperature, the protein solubility decreases due to aggregations and the dispersed protein aggregates make a bi-continuous phase with starch. The aim of this study is to determine the relationship between multi-scale structure and texture of high-protein solid foams with oral destructuration mechanism.

Extruded samples (1.4g) were selected for in-vitro chewing according to their density, cellular architecture, texture, water absorption index of starch and solubility of protein aggregates. In vitro chewing was performed using artificial salivary fluid rate (0; 2; 4 mL/min) and chewing time (5-25s). Shearing angle was 1°, maximum jaw force 350 N and initial volume of saliva 3mL. The boluses were collected at three chewing times. The size distribution of bolus fragments was determined by scanner and image analysis by granulometry. Bolus consistency and saliva uptake were determined by capillary rheometry and gravimetric method, respectively.

Median particle size D50 of dry and humid boluses decreased with chewing time. Dry boluses D50 (0.35-0.75 mm) was found 80% smaller than the one of real chewing, likely due to the absence of fragment agglomeration by saliva. Viscosity of humid boluses exhibited shear thinning behaviour, following a power law with a nearly constant flow index (≈0.11). Bolus consistency index was correlated negatively to saliva uptake, and depended strongly on foam texture. The evolution of bolus properties during chewing, i.e. granulometry, saliva uptake, and consistency were expressed as a function of the foam Young modulus and starch and protein solubility, in order to build a phenomenological model of the oral processing of these foods.

4.2

Mechanical properties affect detectability of perceived texture contrast in heterogeneous food gels

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It is known that many people enjoy to consume foods with texture contrast, such as cookies with soft, creamy fillings or processed cheeses with crispy crackers. Products providing contrasting texture sensations within a bite are generally liked. Little is known about the properties of food components that lead to the perception of texture contrast. The aim of this study was to identify mechanical and physical-chemical properties of foods contributing to the detection of texture contrast as a perceptual heterogeneity within a single bite. Gel-based model foods consisting of two layers were used to systematically vary mechanical and physical-chemical properties between the layers of the foods. By changing the concentration of different gelling agents (agar, k-carrageenan and gelatine) gel layers varying in fracture stress and strain were obtained. The gel layers were combined to gain composite gels differing in mechanical contrast (difference in fracture stress between layers). The detection limit of texture contrast for the food gels was determined using ranking tests where consumers (n=33) were asked to rank the gels in order of increasing perceived heterogeneity. It was found that the detection limit of texture contrast, the perception of heterogeneity within one bite of a composite gel, was largely influenced by the mechanical and physical-chemical gel properties. The detection limit varied between brittle and elastic gels and between soft and hard gels. In soft and brittle gels, heterogeneity was perceived already when the difference in fracture stress between the layers was small. In soft and elastic gels, heterogeneity was perceived only when the difference in fracture stress between the layers was large. In hard gels, the difference in mechanical properties has to be larger in order to be perceived as heterogeneous. We conclude that mechanical and physical-chemical properties of food impact texture contrast and the detection of perceived heterogeneity.

4.3

Modulation of taste intensity using heterogeneous distribution of taste active molecules in liquid foodstuffs

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The food industry is facing great challenges in nutrition since the middle of the 20th century to delight consumer with natural, nutrionally balanced yet tasty offerings. The heterogeneous repartition of tastant (e.g. sodium chloride, sucrose) as means to enhance taste perception without nutritional impact has been investigated for the past decade. The method of choice has so far been to use gels of alternative layered concentration or controlled delivery using gustometers and a record of sensory perception to assess the tested pattern performance. Yet there is neither a scientific understanding of the phenomena, neither a robust pattern that has been identified to trigger a specific sensory modulation.

In this work, a specific pattern enabling to enhance taste perception is predicted using a previously published mass transfer model of taste transport the oral cavity. The pattern is confirmed using gustometry and model liquid food structures. In this way a very significant 80/20 win in paired comparison test (n=24) against a homogenous reference is achieved. Conversely, a 20/80 loss is achieved when the pattern is reversed (n=24) as also predicted by the proposed model.

The approach is then used to enable a significant reduction (up to 50%) in tastant using the taste enhancing pattern with no sensory impact. Such work is thus valuable for the food industry to master its future challenges in nutrition, without compromising sensory perception or using poorly perceived high intensity sweeteners.

4.4

Oral processing behavior of composite foods: interplay between carrier and topping properties

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Oral processing behavior is influenced by structural and textural properties of foods. Consumers frequently combine single foods and consume them together in one bite, for example carrots with dip or coleslaw. Such foods are referred to as composite foods. The individual components of composite foods can differ considerably in composition, mechanical properties and sensory characteristics. Limited knowledge is available about the influence of physical-chemical properties of individual food components on oral processing behavior of composite foods. The aim of this study was to investigate the effect of topping properties on oral processing behavior of carriers presented in different shapes. Carriers (carrots cut in cubes and julienne) and toppings (mayonnaises varying in fat content and viscosity) were combined to create composite foods. Mastication behavior (chewing duration, number of chews, chewing frequency) and bolus properties throughout mastication (recovered bolus mass, saliva content, particle size distribution) were determined for the individual carrots and carrot-mayonnaise combinations. Carrot cubes were chewed for a shorter duration and with fewer chews than carrots cut julienne. Interestingly, these results suggest that pre-cutting does not facilitate oral processing behavior of carrots. Addition of mayonnaise with high fat content or low viscosity decreased total eating time and number of chews until swallowing. Bolus properties were affected by both carrot shape and presence of mayonnaise. We conclude that oral processing behavior of composite foods was dominated by the presence of the carrier rather than the topping. Oral processing behavior of composite foods was affected by its individual food properties including carrier shape, topping fat content and topping viscosity. These insights allow to tailor oral processing behavior and subsequent consumer perception of composite foods.

4.5

Dynamic flavor release from chewing gum: mechanisms of release

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Dynamic flavour release curves from chewing gum were measured using an Artificial Mouth coupled to an AFFIRM®, which measures the release of volatiles in real time. A flavour distribution model for chewing gum is proposed, where flavour is present as droplets in both the hydrophilic (water-soluble) and the hydrophobic (water insoluble) parts of the chewing gum and is present as molecularly dissolved in the hydrophobic part of the gum. During mastication, the flavour droplets in the water-soluble phase are first released and responsible for an initial burst release. The flavour droplets captured in the gum-base are subsequently pushed towards the interface by mastication and are responsible for the second release. The flavour components molecularly dissolved in the gum-base, released only by diffusion, are responsible for the limited release at very long time scales, more than 15 minutes. The release of the flavours from the chewing gum takes place directly through the airflow, simulating breathing, as well as through the waterflow, simulating the saliva and swallowing. Both aspects are significantly important; thus all aspects of the dynamics of flavour transfer have to be taken into account to understand the dynamic release of flavours from chewing gum. The physicochemical properties of five flavour components were related to the release curves of these individual components from the chewing gum. It was found that the oil-water partition constant is an important parameter to explain the flavour release, where hydrophobic components show slower and longer release, while more hydrophilic components show more burst release.

4.6

Tribological Study on Saliva-Tea Compound Mixture: Correlation between Hui Gan (Sweet Aftertaste) Perception and Friction Coefficient

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The Hui Gan (sweet aftertaste) is a delicate sensation perceived after tea drinking, which lasts in the mouth and throat and leads to salivation for an extended period of time. Giving Hui Gan is seen as a key sensory indicator for quality tea brews. This project aimed to reveal the underpinning mechanisms of this sensory feature and its influencing factors. Tribology technique was applied in this study in parallel with the sensory analysis and other physiology assessments. A total of 26 panelists were recruited and trained for tea sensory analysis. Selected tea compounds were used for the study, for instance, ingredient A and B (reported of evoking Hui Gan), ingredient C (reported as sweetener), and ingredient D (reported of tasteless). According to the data observed in the sensory evaluation of tea compounds on Hui Gan perception, 12 panelists were selected and equally divided into two groups: sensitive subjects and non-sensitive subjects. The sensory analysis and tribological measurements were replicated. A self-designed tribometer was applied to measure samples composed of saliva and tea compound, either prepared in vitro as 1:1 mixture of tea brew and human saliva or spitted samples collected after oral processing. The results showed no clear correlation between Hui Gan perception and friction coefficient for non-sensitive subjects. However, the Hui Gan for sensitive subjects was found to be highly correlated with the friction coefficient measured at low sliding speed (< 1 mm/s).

4.7

Oral tribology of protein microgel particles: Influence of hydrophobicity of contact surfaces

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Protein-based microgel particles have attracted significant research attention owing to their enormous technological functionality (1, 2). In this study, we designed whey-protein microgel particles (WPM) (10-80 vol%) and focused on understanding their rheological, structural and tribological properties (smooth polydimethyl siloxane (PDMS) contacts, ball-on-disk set up). The WPM particles (Dh = 380 nm) displayed shear-thinning behavior and facilitated lubrication between bare hydrophobic PDMS surfaces (water contact angle 108○), leading to a 10-fold reduction in boundary friction force with increased volume fraction (≥ 65%). This was largely attributed to the close packing-mediated layer of particles between the asperity contacts acting as 'true surface-separators' and hydrophobic moieties of WPM adsorbing to the PDMS surfaces. The WPM particles are hypothesized to employ a rolling mechanism analogous to 'ball bearings', which was supported by negligible change in size and microstructure of the WPM particles after tribology. An ultra-low boundary friction coefficient, μ ≤ 0.03 was achieved using WPM between O2 plasma-treated hydrophilic PDMS contacts coated with mucin (water contact angle 47○), and electron micrographs revealed that the WPM particles spread effectively as a layer of particles even at low volume fraction (~ 10 vol%) , forming a lubricating load-bearing film. However, above close packing, μ increased in hydrophilic surfaces due to retardation of the rolling mechanism. These findings highlight aqueous lubricating properties of protein microgel particles and hold promises for fat replacements without compromising mouthfeel.

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4.8

Clustering of oil droplets in o/w emulsions enhances sensory perception of oil related attributes

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The clustering of oil droplets in o/w emulsions has been shown to greatly influence the rheological properties and the effective volume fraction of the dispersed oil phase in emulsions. Most studies so far investigated methodologies to create clusters, limited knowledge however is available on how those systems are perceived.

The aim of this study was to research the effect of controlled oil droplet clustering by hetero-aggregation on sensory perception and to relate the observations to physical properties of emulsions. Clusters ranging from 1-50 µm diameter were prepared by hetero-aggregation, by combining emulsions stabilized with positive (gelatine) or negative (whey protein, DATEM) charged emulsifiers. The interaction strength within a cluster was altered by changing emulsifiers (whey or DATEM), and was determined by measuring the critical strain.

A sensory study was performed using the RATA methodology with untrained subjects (n=80). Creaminess and thickness intensities of clustered o/w emulsions were significantly higher than those of homogenous emulsions, and increased with cluster size. While clusters with higher cluster strength were perceived as gritty, clusters of the same size but lesser interaction strength were perceived as smooth.

Rheological properties, such as consistency and flow index, were strongly correlated to thickness and creaminess perception. When mimicking changes during oral processing by incorporating saliva into emulsions, tribology was shown to be correlated to both grainy and fatty perception.

We conclude that clustering of oil droplets in emulsions provides an effective method to structure and redesign foods. Controlled structuring of oil droplets in liquids allows to tune both rheological properties and sensory perception of o/w emulsions. This approach may enable to design low-fat emulsions without thickeners while maintaining sensory perception of the full-fat version.

Theme:

5

Food Texture Insights Through Analytical Assessment in-vivo, ex-vivo, in-vitro

Oral Presentations

5.1

Biomechanical characterization of tongue-food interface during oral processing: an in vitro study with Quantitative Ultrasound

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The development of non-invasive methods is critical for a better understanding of the biomechanical phenomena involved in the dynamic mechanisms of food texture perception during oral processing. The aim of the present study is to investigate in vitro the potential of Quantitative Ultrasound (QUS) to monitor the mechanical properties of tongue-food interface during tongue-palate compression.

Gels of agar and/or gelatin with wide ranges of physical and texture properties were considered as model foods. A tongue-palate bio-mimicking set-up was designed, consisting in a traction-compression machine equipped with tongue and palate phantoms (with varying levels of rigidity, roughness and lubrication). A 1MHz ultrasonic transducer positioned under the tongue was used to measure in real-time the pulse-echo response of the tongue-food-palate system during the compression of the model foods. Signal processing methods were then developed to derive the evolution of the reflection coefficient and of the time-of-flight of tongue-food interface for each compression test. In parallel, 16 trained panelists were asked to describe the intensity of different sensory attributes related to texture perceptions during the consumption of the model foods. The reflection coefficient made it possible to understand how tongue lubrication and food stiffness interfere with tongue asperities during a compression. These indirect measurements of contact area between tongue and food have then been shown to be consistent with the variations of specific texture attributes like moistness or softness. The data on time-of-flight measurements enabled to monitor the real-time deformation of tongue during the compression, which depends both on food and tongue mechanical properties, and were shown to be related to key sensory attributes like stiffness or brittleness.

The study shows the potential of QUS methods for the non-invasive and real-time description of physical phenomena involved in texture perceptions, paving the way for future investigations aiming at transferring of the method in vivo, directly on the consumer. Such a method could be used for the design of food for specific populations, while integrating physiological functions impacting texture perceptions.

5.2

Mechanical insights into the textural perceptions of model beverages – a multivariate approach

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Mechanical insights into the textural perceptions of model beverages – a multivariate approach Piyali Chakraborty1, Dr Heather Smyth2, Dr Torsten Witt3, Dr John Ashton4, Dr David Harris4 and Prof Jason Stokes¬1 1 School of Chemical Engineering, University of Queensland, St Lucia 2 Queensland Alliance for Agriculture and Food Innovation, University of Queensland, St Lucia, QLD 4072, Australia 3 School of Agricultural and Food Sciences, University of Queensland, Brisbane, Australia 4 Sanitarium Development and Innovation, Cooranbong, NSW, Australia

ABSTRACT Interpreting the textural perceptions of food systems through in vitro measurements can generate meaningful insights into the underlying physical mechanisms of these perceptions, which can help in rational product design. However, capturing the "in-mouth physics" through in vitro measurements is still a challenge. The challenge may lie due to the multimodality of texture perception. Our hypothesis is that these multidimensional textural perceptions can be explained using a multivariate statistical approach, relating the complex textural perceptions to the fluids' physical properties.

The sensory properties of model hydrocolloid beverages were modified with the addition of two commercial oat bran fibres that contain varying soluble and insoluble dietary fibre. The beverage matrices were characterised both sensorially and physically using sensory descriptive analysis, bulk rheology and soft tribology measurements. The relationships between the physical properties of the samples and their textural attributes were examined using statistical data analysis techniques (PCA, PLSR). The results show that while thickness is explained through correlation with any viscosity value (within the measured shear stress range), similar correlations (with a single viscosity/friction value) do not exist for complex mouthfeel perceptions, for example – sliminess and particle perception. Instead, these attributes relate with multiple physical parameters of the system — these relationships formulated by Partial Least Square Regression (PLSR) models. The models demonstrate that particle-related perceptions are related to the boundary regime friction and degree of shear thinning of the fluid, while, sliminess-related perceptions are linked to the slope and onset of the mixed lubrication regime and the fluid high shear viscosity. This research decouples the multiple physical attributes potentially relevant for a textural perception, suggesting that multivariate data analysis can be employed to choose the relevant physical parameters for any textural perception. This concept can also be extended to understand the physical origins of the textural perceptions of solid food systems.

5.3

Relating acoustic tribology to in vitro tribology, oral coating and sensory perception

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The application of tribology in food research has revealed important correlations between lubrication properties and perception of foods. Tribology, also called "thin-film rheology", is the study of friction, lubrication and wear of interacting surfaces in relative motion. In relation to sensory perception and oral processing of foods, the tongue and palate represent two interacting surfaces. These two surfaces are lubricated by the adhered mucous layer, saliva and food. The majority of the tribology studies to date has been carried out ex vivo using tribometers. In the current study we present the results of in vivo measurement using acoustic tribology.

In a full factorial design the 8 milk-based products varying in pH (4.2 and 6.8), sugar content (3% and 8%) and fat content (1% and 3%) were studied. The sensory assessment of the samples was done with a QDA panel. The oral coating was determined by FTIR analysis of tongue scrapings. The ex vivo lubrication behaviour of the milk samples was determined by a pin on disc tribometer. The in vivo acoustic tribology was determined by measuring the sound spectra while rubbing the tongue along the palate after swallowing the sample.

Effects of stimulus (8 different) and stimulus factors fat, pH and sugar (2 values each, full factorial) were found, sometimes as main effect, sometimes only in interactions. An increased amount of sugar in the samples tested affected significantly the acoustic measure that was recorded by rubbing the tongue. Most remarkably, it can be noted that High Frequency (2250-4250 Hz) Power Spectral Densities are most sensitive for such effects, whereas HF/LF ratios are entirely insensitive for stimulus composition effects. This leads us to conclude that stimulus effects are mostly found on absolute acoustic volume (no HF/LF effects) and less on shifts in frequency dominance. HF measures appear to be the most sensitive.

5.4

Can in vitro and in silico studies help us undestanding the motor control of swallowing?

Marco Marconati *(University of Surrey), Jan Engmann (Nestlé Research Center), Adam Burbidge (Nestlé Research Center), Marco Ramaioli (University of Surrey)*

Difficulties with food oral processing and swallowing are increasingly prevalent among elderly and patients affected by neurodegenerative diseases. Design of food products and oral medications for improved swallow ability requires an in-depth understanding of swallowing. The existence of an adaptation mechanism of the swallowing motor control pattern to the different perceived structural attributes of the bolus is still debated.

Clinical studies reported greater velocity of the hyoid bone and higher surface electromyography amplitudes when swallowing thicker liquids [1, 2]. The oral and pharyngeal transit time of the bolus is also affected by its rheology [3, 4]. In recent years, in vitro and in silico models have been proposed to gain relevant insights on the role of bolus rheology in geometries relevant to the oral and pharyngeal phases of swallowing. These models simplify the in vivo swallowing dynamics either by imposing strains (displacements) or stresses (forces). This leads to inconsistent results among different studies and sheds doubts about the true predictive power of these models. The alternative approaches of imposing strains or applying stresses are confronted and compared to the in vivo dynamics. The extent to which these simple approximations hold is discussed based on the scientific literature, considering different rheological properties of the bolus. The potential role of the preparatory phase of the bolus is also discussed.

Opportunities for future in vivo studies to bridge the current knowledge gap are also discussed, together with the impact that these studies would have on in vitro and in silico simulations of swallowing.

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5.5

Probing the in-mouth texture perception with a biomimetic tongue

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Recent psychophysics based experimental investigations on both humans and rodents have revealed that the tongue-palate system of mammals possesses remarkable texture discrimination capabilities, which are not fully explained by rheological measurements. Theoretically, a possible explanation of such exquisite sensitivity proceeds from both the tongue softness and its surface topography in the form of papillae.

To explore such possibilities, we have developed a measurement system, biomimetic of the tongue-palate cavity. The artificial tongue is made of a soft transparent elastomer, whose surface is covered with papillae-like structures in the form of cylindrical asperities, and placed at the base of a rheo-optical setup. In place of the palate, we use the upper rotating geometry of the rheometer. Deflections of the top of the papillae are probed using image correlation techniques.

Using well-characterized liquids, we have shown that deformations of the papillae allow determining their viscosity, in quantitative agreement with the recently proposed theoretical model.

5.6

Effect of α-Amylase on Instantaneous Rheological Properties of Tapioca Starch

Shen Siung Wong *(Tate & Lyle), Rachel Wicklund (Tate & Lyle)*

Oral perception of food texture is a complex mechanochemical process. Conventionally, sensory analysis with trained panels is employed to evaluate and describe the mouthfeel of food products. Development of semi-automated processes to mimic human mouthfeel is desirable to accelerate product formulation and development. It is therefore of interest to understand the oral perception of semi-solid foods with instrumental rheological assessment.

Present work aims to evaluate the effect of human salivary α-amylase (two levels of enzyme activity) on the instantaneous rheological properties of starch paste. Commercial native and modified tapioca starch (5%) are suspended separately in salted buffer (pH 6.5) and heated at 95 C while stirring for 6 min. Subsequently, heating is continued without stirring for another 20 min, followed by cooling down to room temperature before subjecting to rheological measurements.

Viscosity of the starches is monitored for 300 s immediately after the addition of α-amylase, at constant shear rate of 50 /s. For samples added with 0.25 U α-amylase, native starch shows a rapid viscosity reduction (more than 10 times) compared to modified starch, for the first 20 s. Starches added with 2.5 U α-amylase show similar reduction profiles, with native starches degraded more.

Oscillatory measurement is performed with constant strain (1%) and angular frequency (1 rad/s) applied to the samples for 300 s. Native starch exhibits a noticeable reduction in complex viscosity, storage and loss modulus around 20 s after the addition of 0.25 U α-amylase. For modified starch, reduction in complex viscosity and loss modulus is negligible. It is interesting to observe that 0.25 U amylase causes a noticeable reduction in storage modulus for both samples, with the effect more profound in native starch. This suggests that amylase is causing a structural breakdown in starch, but with less effect on the viscous component. All rheological results shows acceptable repeatability. In conclusion, present work demonstrates an effective test to explore the possibility of projecting oral textural mouthfeel perception with rheological properties. This work lays a foundation for future work to further correlate instrumental results with sensory evaluation.

5.7

Estimation of physical quantities on human organ surface during oral and swallowing process using novel measurement system “F-bology® analyzer”

Tetsu Kamiya *(Meiji Co. Ltd.), Yoshio Toyama (Meiji Co. Ltd.), Megumi Takai (Meiji Co. Ltd), Motoki Inoue (Meiji Co. Ltd), Takahiro Kikuchi (Musashino Red Cross Hospital), Yukihiro Michiwaki (Musashino Red Cross Hospital)*

Background

Due to the oral process is the complex action with fast movement and configuration changes, it is difficult to visualize the accurate bolus behavior and hard to evaluate numerically using physical quantities (such as force, shear rate, velocity, energy and work) during oral and swallowing process by conventional medical images and measurements. Physical quantities on human organ during oral and swallowing process are considered as important information for the development of the appropriate food product for elderly persons and swallowing difficulties.

Purpose

The purpose of this work is to estimate physical quantities of bolus dynamically on the organ surface received from the food bolus during oral and swallowing process.
Methods　In order to simplified measurement, we have developed“F-bology® analyzer” (FBA) which contained inclined plate with customized wet PVA sheet (pseudo organ sheet). This pseudo organ sheet has similar specific wetting properties of human organ surface. The food sample was supplied on the sheet of FBA by the piston pump, and it became bolus. The bolus flow down and the velocity on the sheet was measured by the disruption signal of laser sensors located on the upper and lower position of side wall of FBA. The changes of the diffusion area of food bolus were calculated from movies recorded by the high speed micro scope set on the vertical direction from the sheet. Physical quantities which include tribology properties on the sheet were calculated from these measured values.

Result and conclusion

Differences of physical quantities such as shear stress, energy density and diffusion area have been observed under the different viscosity, density and drying condition of pseudo organ sheet. The behavior of the bolus flowing down on FBA was considered as similar to human oral and swallowing process qualitatively.

5.8

In-vitro characterisation of bolus pressure, velocity and internal shear of non-Newtonian gelled liquid in a tongue-palate simulator

Andrew Redfearn *(University College London), Ben Hanson (University College London)*

Powdered gums used as thickeners produce shear-thinning fluids and lightly-gelled semi-solid materials; these are perceived as slippery. As well as applications in sauces, dressings and desserts, they are increasingly used in the management of disordered swallowing, "dysphagia", often involving reduced tongue strength and/or sensory-motor control. The hypothesis -examined here- is that shear-thinning behaviour can enable bolus transport of fork-able apparently-solid materials without requiring excessive tongue pressure. This study measured intra-bolus flow and tongue-palate pressure using an in-vitro simulation of the compression and oral propulsion of a bolus.

Materials: Thick & Easy Clear containing xanthan and carrageenan (Fresenius-Kabi Ltd) with Evian (Danone Waters) at concentrations designed to match IDDSI texture levels 1-4 respectively.

Methods: 11ml boluses were subjected to a simulated compression wave between a compliant model tongue (E = 132kPa) and rigid flat palate, being transported 70mm in 667ms. Results: Materials matching IDDSI levels 1-4 had flow indices (measured by conventional cone-plate rheometer) from 0.44 to 0.19 -highly non-Newtonian- and consistency indices from 0.50 to 10.61. Particle image velocimetry was used to measure fluid flow: maximum intra-bolus velocity -centrally- typically increased from 34 to 100mm/s as the compression progressed and internal distribution of shear rate varied from 0 centrally to a maximum at the tongue & palate surfaces (from 12 to 28/s). Pressure was mapped at 5 sensor locations showing an increasing gradient from bolus head to tail. Three stages were identified: initial acceleration (rapid pressure rise); transport phase (relatively constant pressure); clearance (pressure increasing as tongue-palate gap reduces and intra-bolus shear rate increases). Transport pressure (0.06 to 1.55kPa) and clearance pressure (0.14 to 4.50kPa) both increased proportionally with consistency index.

Conclusions: The anatomical simulator provided quantitative evidence of how shear-thinning gum-thickened liquids may facilitate swallowing in dysphagia with a solid, fork-able texture (IDDSI Level 4) requiring only 4.50kPa tongue pressure.

Theme:

6 Impact of Food Oral Processing on Health Benefits

Oral Presentations

6.1

Impact of semolina food structure on mastication and bolus properties – prospects to postprandial glycaemia

Saara Pentikäinen *(VTT Technical Research Centre of Finland Ltd.), Johanna Närväinen (VTT Technical Research Centre of Finland Ltd.), Ulla Holopainen-Mantila (VTT Technical Research Centre of Finland Ltd.), Camilla Melegari (Barilla G. e R.), Kaisa Poutanen (VTT Technical Research Centre of Finland Ltd.)*

Food structure and structure disintegration are relevant factors for digestion and postprandial metabolism. The current study aimed to investigate the mastication process and disintegration of semolina foods of different structures (spaghetti, penne, fresh penne, bread, couscous) after mastication and after in vitro gastric digestion.

The mastication process of 26 participants was monitored using electromyography. Bolus samples obtained from the mastication experiment were pooled and analysed regarding their saliva impregnation, structure disintegration, microstructure and salivary alpha-amylase induced starch hydrolysis. Further, the bolus samples were treated in in vitro gastric conditions and further structure disintegration and changes in microstructure were studied.

Pasta products required more chewing than bread or couscous but resulted in larger particles. Starch hydrolysis, induced by salivary alpha-amylase, was the fastest in bread and couscous boluses, which can partly be explained by the small particle size and thus large surface area for the enzymatic action. Regarding bread, also the high amount of saliva and thus salivary alpha-amylase might in part explain the faster starch hydrolysis compared to pasta. Consistently, bread microstructure seemed to be more easily accessible to the salivary enzymes, as indicated by higher degree of starch granule disintegration in comparison with pasta and couscous. In pasta and couscous, less modified starch granules were detected in the inner parts of the bolus particles. After in vitro gastric treatment, the particle size of pasta products remained reasonably large, whereas the size of couscous and bread particles was clearly reduced.

In conclusion, the semolina products differed after mastication with respect to particle size and starch hydrolysis. These factors are relevant for glucose uptake rate and postprandial glycaemic responses, which has previously been shown to be lower for pasta than for bread. The results highlight the importance of considering structural food features in addition to food ingredients as determinants of digestibility.

6.2

Variation in chewing behaviour among consumers and its impact on digestion

Esther Kim *(The New Zealand Institute for Plant & Food Research Limited), Lidia Motoi (The New Zealand Institute for Plant & Food Research Limited), Arran Wilson (The New Zealand Institute for Plant & Food Research Limited), Suman Mishra (The New Zealand Institute for Plant & Food Research Limited), Shanthi Parkar (The New Zealand Institute for Plant & Food Research Limited), Marco P Morgenstern (The New Zealand Institute for Plant & Food Research Limited)*

There is a large interest in the relationship between food structure, digestion and human nutrition, and many studies explore how food structures are broken down as they traverse the entire gastro-intestinal tract. However, the first stage of digestion, mastication, is often overlooked. In our recent research, we have assessed the chewing behaviour of 120 people and investigated the influence of chewing behaviour on digestion using in-vitro foregut digestion and gut fermentation models. Participants masticated samples of brown rice and expectorated just before the urge to swallow. Chewing behaviour measured by video observations and chewing outcome (i.e. bolus particle size, saliva addition to bolus) varied significantly among individuals, resulting in differences in the digestion of carbohydrates. Long chewers produced a higher glucose in the gastro-intestinal digestion due to the increase in the food surface area and more saliva addition to bolus, whereas shorter chewers produced a higher amount of total short chain fatty acids (particularly lactate) in colonic fermentation due to the larger amount of undigested carbohydrate available for fermentation. Our results have also demonstrated that there is potential to change the gut microbiota by changing the way people chew, without altering diets. Next generation sequencing analysis revealed that the short chewers' microbiome had an increase in the relative abundance of Bifidobacterium and Lactobacillus. This is an important contribution to the growing recognition that the microbiota of the large intestine play an important role in metabolic, nutritional, physiological and immunological processes in the human body. In this presentation, we will present this recent finding addressing the importance of understanding variance in consumer chewing behaviour for designing food products that deliver desired functionalities for target market segments.

6.3

Can oral processing behaviour explain the satiating capacity of yogurts with small texture differences?

Ana Carolina Mosca *(Wageningen University, European Sensory Network), Kees de Graaf (Wageningen University), Jean A McEwan (European Sensory Network), Markus Stieger (Wageningen University)*

Increasing concerns regarding obesity requires a better understanding of factors underpinning food intake. It is well-documented that solid foods are consumed in lower amounts than liquid or semi-solid foods due to longer oral exposure time and lower eating rates. It remains unknown how small texture variations within a product category influence eating behaviour and satiation. This study aims to determine relationships between oral processing behaviour and satiation of yogurts differing in texture. Six iso-caloric combinations of yogurt (thin/thick) with added granola pieces (small/medium/large) were used. Oral processing parameters were quantified by video recording consumers (n=103) eating yogurt ad libitum. Appetite and liking were also quantified.

Texture variations between yogurts were relatively small, but perceivable. Both yogurt viscosity and granola size significantly affected oral processing behavior and intake. A 2-fold decrease in yogurt viscosity was sufficient to increase eating rate, number of spoons, swallows and intake. Large granola pieces (12mm) had the highest sip size and intake, while medium granola (6mm) had the lowest eating rate and highest number of chews. Small granola (<2mm) had the lowest eating duration, number of chews, oral exposure time, sip size and highest eating rate, number of spoons and inter-spoon interval. The lowest intake was observed for thick yogurt with small granola pieces. This impact of texture properties on satiation cannot be fully explained by product liking, oral exposure time and eating rate. The appearance of this yogurt might have elicited higher expected satiating capacity, as the combination of thick yogurt matrix with small granola pieces resulted in a denser product. We conclude that small but perceivable variations in texture properties of yogurt (variation of 2-fold in yogurt viscosity and 6-fold in granola size) are sufficient to change oral processing behaviour and intake. The satiating capacity can therefore be modulated without changing drastically product identity.

6.4

Nutrient bioavailability is reduced in elderly with oral deficiency: interest of combining in vitro mastication and digestive approaches

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The first stage of digestion of solid foods begins with the food oral processing. The way in which the food bolus formation is achieved during mastication will define further digestive steps and consequently nutrient bioavailability.

This work was designed to study the impact of masticatory deficiency, frequently observed in elderly population, combined with aged digestive characteristics on nutrients bioaccessibility after ingestion of a meat model food.

Four combinations of oral and gastric digestive conditions were simulated: in vitro food boluses were obtained after normal or deficient mastication by programming the mastication simulator AM2 and were digested in an in vitro dynamic digester (DIDGI®) mimicking adult or elderly physiological gastric conditions. Physical characterization of food bolus material was obtained with granulometry and rheological measurements. Biochemical characteristics of the liquid phase of the bolus (lipids/proteins oxidation, free-iron/peptides release in liquid phase) were measured for nutrient bioaccessibility assessments. The kinetics of release of lipids, proteins and peptides from the food matrix during gastric digestion were assessed in digesta (collected after 30, 60, 90, 120 and 150min) and analyzed as the area under the curve of nutrient appearance.

Results showed that (1) food bolus after deficient mastication were harder, more cohesive and less disorganized, and with a greater proportion of large particles (2) deficient mastication resulted in a reduced bolus bioaccessibility of free-iron and peptides (3) deficient mastication slightly impacted nutrient bioaccessibility in gastric digesta after adult digestive conditions, probably balanced by the gastric enzyme activity and acidic conditions (4) deficient mastication combined with the elderly digestive conditions delayed the release of nutrients in the gastric compartment and did not reach the threshold obtained during adult digestion.

Obviously for designing specific food for elderly, the oral stage has to be carefully considered to fulfill the specific needs of the elderly population whom increase dramatically.

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6.5

Relationship between nutritional sucking habits, taste sensitivity, food consistency and body mass index in children: a multivariate analysis

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As feeding and sucking habits may be interrelated and also associated with taste and body composition, the objective of this study was to perform an exploratory analysis to identify groups of children in a way that the degree of association between intragroup subjects is maximal, providing an explanation and interpretation of the data collected. For this purpose, 354 prepubertal children were enrolled (197 girls; age range= 84-139 months), from whom the following variables were examined: time of breastfeeding, time of bottle-feeding, taste sensitivity (for sweet, salt, bitter and sour in four different concentrations), body mass index (BMI), and food consistency (using a proxy questionnaire). In addition, the salivary concentrations of amylase and total protein were determined. Data were submitted to exploratory analysis, normality test, cluster analysis (K-means), one-way ANOVA and correlation test. The analysis identified three reliable and meaningful clusters, which varied by nutritional sucking habits, taste sensitivity, BMI, food consistency, and age. A pattern of subjects with a longer breastfeeding and shorter bottle-feeding time, lower BMI and higher food consistency was observed, with significant differences ($p<0.05$). In addition, a group of older children with higher taste sensitivity was identified. No correlation was found between salivary amylase and total protein concentrations, taste sensitivity and BMI, although taste sensitivity showed to be higher among girls. Identifying patterns of grouping of nutritional habits may help health professionals provide infant and young child feeding counseling.

6.6

Impact of food formulation and processing on saltiness perception

Miroslaw Kasprzak *(University of Nottingham), William Macnaughtan (University of Nottingham), Stephen Harding (University of Nottingham), Peter Wilde (Quadram Institute Bioscience), Bettina Wolf (University of Nottingham)*

One of the salt reduction strategies in liquid food products can potentially be a programmable salt delivery using water-in-oil-in-water (wow) emulsions stabilised by chemical modified octenyl succinic anhydride (OSA)-starch (Chiu et al. 2015). The objective of the current study was to investigate the effect of formulation and processing conditions of wow emulsions stabilised by non-chemical modified starch on the droplet size stability and salt release using an in vitro oral cavity model.

The emulsions were produced with high and low (0.27 and 0.57%) contents of internal lipophilic emulsifier polyglycerol polyricinoleate (PGPR 90Kosher, Dupont, DK) and 2, 3 or 4% of external hydrophilic emulsifier, either OSA-starch (Univar, UK) or native waxy rice starch (Ulrick & Short, UK). The formulations were processed in a high shear overhead mixer (Silverson, UK) operating at 8000rpm, leading to a production of emulsions at low (75±3°C) and high (88±5°C) temperature.

The results showed that all emulsions were stable against coalescence for at least three months. The droplet size was smaller in OSA-starch emulsions compared to waxy rice starch based emulsions. The salt encapsulation of all emulsions remained stable for at least 3 months with the exception of OSA-starch emulsions and Low Temp Low PGPR waxy rice emulsions. Reducing PGPR content led to an increase of salt detection in emulsions processed at low and high temperature. High temperature processing increased the salt detection at high PGPR emulsions stabilised by 3 and 4% waxy rice and, at low PGPR emulsions stabilised by 2, 3, 4% waxy rice starch, resulting up to 90% salt detection.

The chemical modified starch can be replaced by native waxy rice starch for the controlled release of salt. The salt release varies depending on formulation and processing condition of emulsions. The future work will focus on the salt reduction in wow emulsion based foods.

Theme:

7 Designing Foods for Enhancing Sensory and Consumer Experience

Oral Presentations

7.1

Chewing efficiency in 6 to 18 months old children: evolution with age and relationships with food texture acceptance

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Chewing skills start to be learned between 6 and 12 months and greatly develop during the two first years of life. However, so far the evolution of chewing efficiency has only been indirectly characterized in infants, because the methods applied in adults are not very suitable for infants. We recently developed a method based on a gel enclosed in a feeder, specifically adapted to measure chewing efficiency in infants and toddlers (Tournier et al., 2015). In this study we evaluated how this measure of chewing efficiency could predict children's acceptance of solid foods varying in textural properties. Measurements were performed in a longitudinal study involving 2 groups of children: G1 (n=25), followed at 6, 8 and 10 mo and G2 (n=24) followed at 12, 15 and 18 mo. Chewing efficiency was evaluated from the ability to break down a gel enclosed in a feeder into particles via oral processing. Texture acceptance was determined from the ability to process and swallow foods of various textures (smooth and rough purees, cooked and sticky pieces, raw and hard foods).

Children's compliance to the method was lower in G2 children than in younger ones (G1). Chewing efficiency increased with age: as children grew up their ability to break the gel into more particles increased (10±2 particles at 6 mo to 278±30 at 18 mo). Inter-individual differences in the number of bolus particles were explained by differences in individual oral processing strategy (sucking vs. biting on the gel) and dentition for G1 children, and were found to predict food texture acceptance between 12 and 18 mo for bread and biscuit but not for food pieces. This suggests that the crushing action of chewing cannot solely explain children's ability to process food and that other parameters (e.g. tongue mobility) should also be considered.

7.2

A mathematical model of the bolus formation of starch-based foods during oral processing

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Food oral processing is one of the many digestive processes in the body but is less understood due to its complexity and variation across people. A mechanistic approach, such as a mathematical model, is a tool that can be used to understand food oral processing. It can be used to visualise the mechanisms and governing principles of oral processing when food is consumed in the mouth. Similarly, the models could be used to identify food structures aimed at providing palatability with increased protein, reduced sugar or salt products. Therefore a successful outcome of the mathematical model can provide understandings to food engineers to design foods that can tailor to consumer preferences.

It is known that food oral processing involves various small batch operations, including mechanical shear, heat transfer, enzymatic reactions and many others. In this research, these operations were compared with the unit operations currently existing in the food and chemical engineering industry to offer insights and a basis for the development of a mathematical model. For example, food particle reduction by the teeth is paralleled to crushing a rock ore using a jaw crusher in the engineering industry. The mathematical model predicts starch-based food (such as rice, biscuits and potato chips) bolus properties which are known to have an impact on swallowing, digestion and palatability. The modelled properties are the particle size distribution of the bolus, the bolus continuous phase viscosity, the concentration of tastant and aroma compounds inside the bolus and the bolus cohesiveness. The study is divided into three principal stages; first is the development of a conceptual model to provide a framework of the key rate processes involved in oral processing, second is the development of a working mathematical model integrating these essential processes and lastly validating the mathematical model with in-vivo experimental data.

7.3

Exploring the use of sensory tools to classify commercial dairy products for dysphagia sufferers

Maeva Cochet-Broch *(C.S.I.R.O.), Anoek van der linden (former Wageningen), Aarti Tobin (C.S.I.R.O.), Astrid Poelman (C.S.I.R.O.)*

Current Australian standards for texture modified foods and fluids describe six categories based on viscosity (fluids) and particle size (foods). Depending on the severity and origin of swallowing difficulties, dysphagia sufferers are advised to consume products falling into particular categories. However, ready-to-eat food products specifically designed for dysphagia sufferers are scarce and patients often have to prepare food themselves or purchase non-specialised food increasing the risk of hazardous situations.

Using sensory analysis tools, the objective of this study was to determine the perceived in-mouth textural characteristics of products known to adhere to the texture modified food guidelines, and to apply those insights as a first step to classify dairy products available in Australia with a view to provide a greater choice to patients.

Using a trained panel, we developed a sensory vocabulary of 17 attributes describing the texture of 22 ready-to-eat foods designed for dysphagia sufferers. In parallel, 50 semi-solid commercially available dairy products from the Australian market were sorted by a panel of healthy subjects based on their textural properties, and 16 products were selected as representative of different clusters. The previously developed texture vocabulary was then used to profile the texture properties of the dairy products. Results of both profiles were combined to classify dairy products into the different texture-modified foods and fluids categories described in the guidelines.

With the exception of 2 products containing large particles , all dairy products analysed shared textural characteristics with products specifically designed for dysphagia sufferers and could be classified in one of the categories described by the Australian guidelines. By extrapolation, other dairy products could be graded based on their texture properties. Validation of ease of swallowing of these products with dysphagia sufferers will be required for these products to be used by dietitians and speech pathologists.

7.4

Exploring temporal methods to assess dynamic product profiles

Louise Hewson *(PepsiCo), Emily Chang (University of Nottingham), Qian Yang (University of Nottingham), Peter Herring (PepsiCo), Rebecca Ford (University of Nottingham)*

Background: Current products are designed to supply multi-sensorial experiences, delivering a complexity of texture and flavour which change over time. In additional, products are ever more frequently designed to address specific target group needs (eg children, elderly) and understanding the temporal profile during oral processing is critical to design. To uncover the perceptual journey experienced we need to utilise novel and emerging methodologies to harness information providing actionable product insight enabling developers to achieve their ambitions. This study aimed to explore and compare the evolving techniques (TDS, TCATA, TOS), using in market products to exemplify dynamic product profiles.

Method: 54 consumers used 4 different temporal methods; Temporal Liking (TL), Temporal Dominance of Sensations (TDS), Temporal Check-all-that-apply (TCATA) and Temporal Order of Sensations (TOS), as well as providing Classical liking scores using 9pt hedonic scales. Products (2 spicy/chili crisp products) were presented as a series of portions (6) to realistically represent the consumer experience during normal consumption. Results Results indicated consumers were able to perform even the more challenging method of TDS with relative ease. Differences were identified in texture and flavor attributes, both between products, and across product portions, highlighting the need for multiple samplings to capture a full product profile.

Discussion: Although the temporal methods identified similar temporal evolution of sensory attributes for each product, it was clear that TDS and TCATA provided a greater depth of information compared to TOS, and TCATA appeared to give a broader range of attributes compared to TDS, which may be important for product discrimination of complex products. Both TDS and TCATA were able to capture lingering sensations which TOS did not, although TOS was considered the easiest to use by consumers. All methods provided slightly different output emphasizing the need to have a clear objective when performing temporal assessments which will guide the decision of correct methodology.

7.5

Parent-reported food texture preferences and texture sensitivity in young children with and without Down syndrome

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Food texture has been identified as a major issue regarding feeding problems in children and thus exploration into this research area is of great interest. In this study, we examined the open-ended survey responses of caregivers describing which food textures were considered to be 'easy' or 'difficult' for their child.

Using caregiver responses to five key questions, children (between 1-4 years) were assigned to a texture sensitive (TS) or non-texture sensitive (NTS) group. Due to the increased likelihood of texture sensitivity in children with developmental delays, in addition to caregivers of typically developing children (n=573), caregivers of children with Down syndrome (DS) (n=157) were also included in this study. Following the completion of the survey, the open-ended responses from the caregivers about textures and foods they considered 'easy' or 'difficult' for their child (n=2924 textures or foods) were coded into 32 texture categories post-hoc.

Results showed the citations of 'easy' textures were negatively influenced by a Down syndrome diagnosis in the child and the total number of comments listed by the caregiver ($p<0.05$). The interaction between age and texture sensitivity of the child also played a role, with age having less of an impact in the TS children compared to the NTS children in their reports of 'difficult' textures ($p<0.05$).

The citation of specific textures as 'easy' or 'difficult' also varied. Among TS children, caregivers stated textures such as dry, mealy and smooth as being 'easy' whilst chewy, rubbery and tough were reported to be 'difficult' ($p<0.05$). Among children with Down syndrome, tender and mushy were reported as 'easy' while lumpy, tough and gritty were reported as 'difficult' ($p<0.05$).

These results demonstrate that caregivers identify different textures as being challenging for their children based on TS and the presence of a Down syndrome diagnosis.

7.6

Oral processing behaviour of liquid, semi-solid and solid foods differs between consumers varying in age, gender and ethnicity

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Food oral processing is the first stage of human digestion, during which food is transformed into a bolus that can be safely swallowed. How food is handled inside the mouth depends for instance on the oral physiological characteristics of the individual consumer. It has been shown that with ageing muscles weaken and movement coordination during oral processing declines, complicating the eating process for elderly. The ability to masticate and swallow foods between genders and ethnicities might impact oral processing behaviour. The aim of this study was to determine the effect of age, gender, ethnicity and eating capability on the oral processing behaviour of liquid, semi-solid and solid foods. Oral processing behaviour was assessed for 3 groups of healthy consumers, Dutch adults (18-30 years, n=32), Chinese adults (18-30 years, n=35), Dutch elderly (65-85 years, n=29) and a fourth group of consumers with mild, self-reported swallowing problems and/or low mastication efficiency (18-85 years, n=39). Participants consumed 18 commercially available foods covering a wide range of physical properties, including liquid (drinkable), semi-solid (spoonable) and solid (chewable) foods. Participants were video recorded during consumption and bite/sip size, consumption time, number of chews and eating rate were obtained. Older consumers were characterized by having a longer consumption time, higher number of chews and lower eating rate compared to young consumers. Males consumed foods with larger bite size and higher eating rate than females. Asian consumers had a smaller bite size and lower eating rate compared to Caucasian consumers. Consumers with mild swallowing problems did not differ in their oral processing behaviour from healthy consumers. This might be due to the relative minor differences between this group and the healthy consumers. We conclude that age, gender and ethnicity influence oral processing behaviour of liquid, semi-solid and solid foods differently.

7.7

Perception of vanilla ice creams: does portion size matter?

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In current days, consumers want and expect food products of superior quality that are healthy and tasty. We need to understand how products are perceived and liked by the consumer, and for that we should consider the dynamic consumption journey of the eating experience.

Currently, the food industry is using a few tools to capture the consumer experience during the consumption of a food product. However, present techniques may have limitations. On the one hand, quantitative descriptive analysis captures the sensations at a given moment in time and usually after only one bite / spoon of a food product, which may not reflect the full eating experience. On the other hand, time-intensity or temporal dominance of sensations help capturing the dynamic of the consumer experience in a more holistic way, but such techniques are time consuming and not suitable as fast screening tools with a large number of consumers.

In this context, the aim of our study was to investigate the temporal aspects of sensory / hedonic / emotion assessments with a fast and simple methodology to understand whether assessing products after one spoon is a good approach to capture the overall eating experience. For that matter, participants were recruited and asked to eat two ice cream products varying in sugar content. Part of the participants consumed a single one-bite portion size of both ice creams and assessed liking, sensory and emotional attributes after that single bite. The other part of participants was asked to eat a full standard portion size of both ice creams and to assess the liking, sensory and emotional attributes at three consumption points (start, middle end of consumption). Key highlights of this study will be presented and discussed during the conference.

Themes:

1 & 2

Oral Physiology and Dentistry

Posters

P 1

Development of jaw sensorimotor control and chewing - a systematic review

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IMPORTANCE Mastication is a complex sensory-motor interaction between the central nervous system and the oro-facial structures. To understand the effect of oro-facial abnormalities on mastication, it is important to first understand the normal development of mastication in healthy children.

OBJECTIVE To study the normal development of sensory-motor control and chewing in healthy children.

EVIDENCE REVIEW Original studies which investigated four main objective parameters of chewing, i.e. bite force, electromyography (EMG), jaw movement and oral food processing in children were systematically searched using three established databases. The targeted sample were healthy children from the age of 6-months to 18-years. All studies that subjectively assessed mastication, studies of children with abnormalities, or non-English studies were excluded.

FINDINGS A total of 6168 papers were identified, 52 met the final inclusion criteria. Results are presented according to the dentition stage. Children below 6-years (primary dentition) had lower biting forces and EMG activity, and the frontal jaw movement pattern was more laterally displaced and less stable compared to children older than 6-years. EMG activities and bite forces were increased in children 6- to 10-year-old (early mixed dentition) with a reduction in lateral jaw displacement and an increase in vertical jaw displacement. Twelve-year-old children were able to chew food into smaller particles compared to 6-year-olds. Gender differences were visible in all parameters except EMG activity in late mixed dentition (10- to 12-years). After 12-years, there was a significant increase in bite forces and EMG activities, and the frontal jaw pattern became similar to adults.

CONCLUSIONS Studied chewing parameters gradually improve with the development of the oro-facial structures and were mainly influenced by dental eruption. A significant development of all chewing parameters occur after 12 years of age. A translation to the adult-type of masticatory performance occurs between 10- to 14-years of age.

P 2

New insight into the role of the oral mucosa in flavour perception

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Flavour is one of the main factors guiding food consumption and acceptability. It corresponds to the complex combination of the olfactory, gustatory and trigeminal sensations perceived during eating. It results from the activation of different receptors by flavour compounds as a function of their affinity. During eating, flavour compounds dissolve into saliva, before reaching taste and trigeminal receptors or evaporating and reaching the olfactory receptors via the retro-nasal way. In saliva, flavour compounds are more or less prone to interact with salivary proteins depending on their structure. These interactions have been reported to play a role in flavour perception. A part of salivary proteins is anchored onto the epithelial cells surface forming a structure called the mucosal pellicle, which ensures the lubrication of the oral cavity. It has been hypothesized that flavour compounds also interact with these proteins and that these interactions could be involved in the perception of astringency and aroma persistence. To study these interactions, our strategy was to develop a new model of oral mucosa taking into account for the first time the mucosal pellicle. Then, this model mucosa was used to study its effect on aroma release and the impact of astringent compounds on the structure of the mucosal pellicle.

Our results show that the release of aroma compounds from the mucosal surface depends on their structure, through different mechanisms (i.e. metabolization and non-covalent binding).

Moreover, our results bring new insight on the molecular mechanisms at the origin of astringency. Indeed, we have shown that tannins, which are astringent compounds, aggregate the proteins of the mucosal pellicle leading to an increase of the friction force at the cell surface. When the salivary proline-rich protein IB5 (which is known to bind tannins) is present, aggregation decreases, indicating that proline-rich proteins play a protective role towards tannins in saliva.

P 3

Astringency-induced reduction in flavour intensity of Brussels sprouts

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The perception of bitter tastants occurs via the well characterized family of taste receptors (TAS2R) within taste buds located mostly on the tongue. Whereas astringency is a mouthfeel phenomenon perceived mostly by the oral mucosa, particularly on the labial and palatal surfaces.

Typically astringency involves an interaction of salivary proteins (proline-rich proteins, histatins and mucins) with polyphenols whereas no role has been suggested for saliva in the perception of bitterness.

Some previous reports have reported an association between bitterness perception and levels of carbonic anhydrase 6, cystatin SN or proline-rich proteins.

In this report we use the well described bitterness of Brussels sprouts and assess whether three interventions (wine, gravy or water) affect the flavour intensity. To a group of 28 untrained subjects two quarters of cooked sprouts were first assessed by a labelled VAS for flavour intensity.

Following a sip of the intervention two more segments of sprouts were tasted and assessed, this was repeated for all interventions. Interventions were presented in a randomized order across the group. Only red wine affected the perception of the Brussels sprouts, causing a 2 point reduction in flavour intensity ($p<0.001$, Tukey test).

Since the water and gravy intervention did not affect flavour intensity it seems unlikely that dilution or temporal dominance explains the effect of the red wine. A possible explanation is the depletion of salivary proteins by the polyphenols in wine affected the transport of bitter substances to taste buds.

This suggests that salivary proteins do facilitate the tasting of bitter substances.

P 4

Using the International Classification of Functioning, Disabilities and Health to evaluate Food Oral Processing in older persons: a reliability and validation study

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There is no gold standard within Health-Related Patient-reported Outcomes to evaluate Food Oral Processing (FOP). The International Classification of Functioning, disability and health (ICF, World Health Organisation, 2001) is a comprehensive model for describing human experience in terms of body structure, body function, activities and participation. It provides an exhaustive list of over 1400 items related to body structure, body function, activities and participation, and environmental factors. This study evaluates the validity and the reliability of a formative model questionnaire composed of a set of 10 ICF items related to ingestion function in order to propose its use for FOP measurements.

A convenience sample of 50 older persons, including 22 women (mean 71.7±4.5 yrs) and 28 men (mean 71.6±5.3 yrs), twice completed an online questionnaire. It included ten items on difficulty with activities and participation relating to ingestion functions (biting, chewing, manipulating food, saliva production, swallowing; taking care of the teeth, eating, drinking, taking care of general health, preparing meals).

After clinical examination and salivary flow (SF) measurements, participants were classified into two categories: poor oral status (less than 5 posterior functional dental units (PFU), with or without a denture, and/or with a stimulated SF <1ml/mn, and/or with a rest SF<0.25ml/mn) or good oral status (at least 7 PFU and a stimulated SF >1ml/mn, and with a rest SF>0.25ml/mn). Moreover, participants chewed a two-coloured gum for 20 cycles, and the colour heterogeneity was measured by image analysis. High Intra Class Coefficients between test and retest rounds demonstrated good reliability overtime for all items. Construct validity was based on the following hypothesis: individuals declaring more difficulties for the items “Biting”, “Chewing”, “Food manipulation” and “saliva production” had poor oral status and provided a less mixed chewing-gum sample than subjects declaring no difficulties for each items. The hypothesis was verified. "This work/study was supported by the French AlimaSSenS project (ANR-14-CE20-0003)"

P 5

Salivary antioxidant status: a key parameter involved in the release and perception of sensory stimuli in human

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Saliva plays a major role in taste and olfactory functions. After being released from the food matrix, flavour compounds (taste and aroma) dissolve in saliva and can reach gustatory receptors for taste or olfactory receptors via the retronasal way for aroma. Saliva also takes an important part in the maintenance of taste-sensing cells. Thus, it is not surprising that flavour perception can be modulated by salivary properties. Among them, total antioxidant capacity (TAC) has been linked to fat taste in middle age subjects, aroma release in obese subjects and eating difficulties in children.

In this context, two experiments were performed on specific populations in order to investigate the role of salivary TAC in flavour perception.

The first one was conducted on subjects expressing taste disorder (n=80) or not (n=40). Saliva was collected at rest and analysed (TAC and related enzymes). We observed that taste disorder subjects presented a significantly increase of TAC which was associated with significant higher levels of salivary catalase and superoxide dismutase.

The second study was performed on elderly subjects presenting low (n=15) vs normal (n=15) salivary flows. Aroma release was measured after incubating the stimulated saliva samples in presence of 3 aroma compounds (ethyl-hexanoate, octanal and 2-nonanone). Results showed that aroma release was different between both groups and correlated negatively to the levels of salivary TAC. We suspect that octanal and ethyl-hexanoate were metabolized enzymatically since their metabolites octanol and hexanoic acid were detected. Altogether, these results strongly suggest that salivary antioxidant status plays a major role in the modulation of flavour release and perception at the level of the oral cavity. Understanding the underlying mechanisms represents a major scientific issue in the field of flavour perception in humans and particularly in specific populations. This study was supported by French AlimaSSenS (ANR-14-CE20-0003) and Muffin (ANR-14-CE20-0001) projects.

P 6

Morphological and Performance Variation of Mouth Behavior Groups

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Recent work has tied food texture preference to food choice, described as mouth behavior groups, across a broad sample of people. From these studies, four mouth behavior groups were identified that describe most people: chewers, crunchers, smooshers, and suckers. Individuals were asked to indicate preferences for various foods with textures that best supported the four mouth behaviors. These behavioral preferences for feeding styles are thought to play a significant role in food choices and decisions in consumer purchasing. While these behavioral groups play a role in food selection, it is unknown how closely they relate to basic body and oral cavity metrics, masticatory apparatus performance, and oral processing during chewing. Our objective was twofold: to determine if mouth behavior groups are related to 1) morphological variation in body size and head measurements as well as 2) masticatory apparatus performance. We asked participants to complete an online mouth behavior assessment followed by collection of basic body and head measurements. We also measured participants' maximum jaw opening abilities (gape) and maximum bite forces at the incisors and molars.

As expected, we observed associations between masticatory performance and overall body as well as oral cavity size across our sample. Preliminary results, however, suggest no strong associations between mouth behavior groups and metric or performance data. A trend was observed where head width tended to increase from suckers and smooshers to chewers and crunchers, but this association was only suggestive. Based on these results, mouth behavior groups are not closely related to size or masticatory performance, suggesting other factors primarily drive food texture choice and preference in these individuals.

P 7

The Influence of Salivary Metabolites on Oral Perception

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It is known that the metabolite composition of many foods and drinks can influence a range of perceived qualities, including underlying basic tastes (1,2). Importantly, the metabolic composition of saliva may play a role in influencing oral perception (3), although this is a largely unexplored research area.

We have recently shown that many of the metabolites that make up whole mouth saliva (WMS) are derived from microorganisms in the oral cavity. These include short-chain fatty acids (acetate, propionate, butyrate), amino acids (glycine, phenylalanine), organic acids (succinate, pyruvate) and amines (methylamine and dimethylamine). Other metabolites can be of both host and microbial origin (lactate, citrate and urea).

This work aimed to investigate whether the metabolite composition of saliva can influence the perceived intensity of basic tastes (sweet and bitter) and Transient Receptor Potential (TRP) mediated oral sensations.

Unstimulated WMS was collected from healthy volunteers, (n=15). Salivary metabolite composition was analysed by proton nuclear magnetic resonance. Participants rated 0.25M sucrose, 8mM caffeine, 250ppm menthol and 1ppm capsaicin solutions for sweet, bitter, cooling and warming intensity, respectively. Ratings were performed on an eleven point labelled magnitude scale.

Several metabolites were found to be significantly more concentrated in low perceivers than high perceivers of sucrose sweetness, ($p<0.05$). These were lactate, succinate, glycine, butyrate, propionate, formate and alanine. Propionate was found at higher concentrations in low perceivers of caffeine bitterness compared to high perceivers, ($p<0.01$). No metabolites were found to differ between low and high responders to menthol or capsaicin.

These results imply that some salivary metabolites may have a role in influencing taste perception. Propionate is particularly interesting as it is typically the second most concentrated salivary metabolite after acetate, and may exceed threshold concentrations in some cases. Differences in salivary metabolite composition, reflecting different oral microbial composition, may help explain inter-individual variation in taste perception.

1. Straadt et al., 2014. Meat. Sci. 96;2:719-728. 2. Kodani et al., 2017. Sci. Rep. 2;7:1297 3. Mounayar et al., 2014. Metabolomics. 10;4:688–696

(Flash Poster Presentation)

P 8

Anticipatory thirst is unrelated to salivary changes but is modified by food intake

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Osmoreceptors in the brain trigger thirst when the plasma osmolality increase too high and other associated mechanisms to restore fluid balance upon existing water deficit. Thirst is a subjective perception that modifies behaviour which resulted in drinking. It is usually associated with dry mouth and other oral subjective changes. However, the relationship between thirst and oral changes is still not fully understood. This study was aimed to determine if oral physiological changes were associated with thirst perception in a normal hydrated and dehydrated group.

In the normal hydrated group, thirst perception in ten healthy individuals was evaluated over the course of 6 hours with hourly unstimulated whole mouth saliva (UWMS) collection. While the dehydration group, we collected UWMS and assessed thirst and dry mouth perception in sixteen healthy participants before, during, after and 2-hour after a moderately strenuous exercise. Salivary flow rate, spinnbarkeit, osmolality, protein, electrolytes, and mucins were investigated.

Findings from the hydrated and dehydrated groups showed that thirst is independent of salivary flow rate and variations in thirst perception were observed. Thirst correlated significantly with dry mouth and salivary osmolality in the dehydrated group which was associated with salivary protein and potassium concentrations. However, salivary osmolality was also seen to be related with salivary protein and potassium concentrations in the hydrated group.

In conclusion, the hydrated group may have experienced an anticipatory thirst while the dehydrated group have homeostatic thirst secondary to hyperosmolality. Salivary osmolality could contribute to homeostatic thirst but not for anticipatory thirst. Thus, the association between thirst and salivary osmolality may support the oral mechanism of thirst as determined by the findings in salivary protein and potassium. Therefore, either a receptor for osmolality or osmolality affecting the lubrications properties of mucins in saliva could be the potential mechanism of people are feeling thirsty orally.

P 9

Coordination of oro-pharyngeal pressures during swallowing of thickened water

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Introduction Oro-pharyngeal swallowing is a complicated process which involves the coordination of multiple anatomical structures. Additionally, appropriate propagation of pressure is required to propel a bolus from the oral cavity to the esophagus. However, little is known about the synchronicity of tongue and pharyngeal pressure propagation. This study aimed to measure tongue and pharyngeal pressure and to clarify the relationship of pressure generation during thickened water swallowing.

Materials and Methods 12 male and 8 female healthy volunteers participated. Tongue and pharyngeal pressures were simultaneously measured using a sensor sheet system and high-resolution manometry respectively. The sensor sheet for measuring tongue pressure is 0.1 mm thick and has five pressure sensing points. The sheet was attached to the palatal mucosa directly. The high-resolution manometry catheter has 36 sensors, located one cm apart, and is inserted transnasally into the pharynx and cervical esophagus. Participants swallowed 10ml of thin liquids, nectar (150mPa·s), and honey (400mPa·s) viscosities. Pressure magnitude, duration, and timing of pressure were compared among tongue and pharyngeal sensors.

Results and Discussion Either tongue pressure or pressure at the velopharynx appeared first, and the onset of tongue pressure was earlier than that of upper esophagus sphincter (UES) opening. Magnitude of tongue pressure was lower than pharyngeal pressures and the duration of tongue pressure was longer than the duration of UES opening. Pressure magnitude and duration were similar among the viscosities. However, the speed of propagation during honey swallowing was slower than thin liquid swallowing, and the duration between the onset of tongue pressure and UES closure during honey swallowing was longer than that during thin liquid swallowing.

Conclusion This study suggests that tongue and pharyngeal pressure are generated in a coordinated pattern. However, this coordination appears to be food texture dependent.

P 10

Behavioral learning and skill acquisition during a natural yet novel oral manipulation task

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Objective: To investigate the effect of short-term training on behavior learning and skill acquisition during a natural yet novel oral manipulation task.

Methods: Thirty (18 women) healthy volunteers in the age range of 18-32 years were recruited and divided into two groups on the basis of their familiarity to perform a complex oral motor task. The volunteers participated in a single experimental session divided into three sets. Each set consisted of three series, each with ten trials of a standardized behavioral task. The task was to position, split and retrieve a sunflower seed from its shell without damaging the seed. The two consecutive sets were separated by fifteen minutes of short-term training. During the short-term training, the participants practiced and repeatedly performed the behavioral task. A five-point grading system was devised to determine the performance scores of the participants during the behavioral task. Further, video registrations with a GoPro© camera were done to determine the duration of the task. The data were analyzed with three-way ANOVA for repeated measures.

Results (preliminary): There was a significant effect of training on the task performance scores ($P<0.001$). The non-familiar group performed significantly better after training ($P=0.0001$). However, the familiar group took significantly shorter time to complete the task than the non-familiar group. Overall, there was a significant negative correlation between the average score of every split and the average time to perform the split ($R=-0.432$; $P=<0.000$).

Conclusion: The results of the present study show a significant effect of training on the performance of a complex oral motor task. Training results in improved performance scores and a decrease in duration of the task. Training or learning of oral motor tasks could be important to optimize masticatory performance in dental prosthesis users and may represent a much-needed paradigm shift in the approach to oral rehabilitation procedures.

P 11

A saliva study assessing the accuracy/management of palate cleanser in wine tasting and astringency feeling

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Palate cleansers (PC) are used to remove food components retained in the oral cavity during sensory evaluation. In wine tasting, due to its high sensory stimulations, PC are widely used, in special for astringency feeling; however their conventional selection and use are mainly empirical. The aim of this work is to study the relation between the components retained in saliva after wine tasting and the remnant sensory feeling (astringency, alcohol and acidity). For that, different common palate cleansers (water, carbonated water and milk) were tested and saliva samples (expectorated and scraped) from 9 trained panellists were collected after wine/wine+PC trials. Furthermore, total polyphenols and basal proteins content in saliva samples were measured and correlated with the sensory evaluation at two times (immediately after PC use and one minute after that). Analysis of variance was applied to study the differences in sensory scores among PC and times (Tukey test at significance $p < 0.05$). A paired T-test was done to compare the total polyphenol content of both types of saliva samples (expectorated and scraped). Pearson's correlations between all sensory scores and analytical data were also calculated. Results showed that after palate cleaning or not cleaning, astringency, alcohol and acidity feeling were influenced by time, PC and panellist. Astringency feeling showed the greatest intensity of these three remnant sensations, milk was the only PC which dragged down polyphenols quantification in expectorated saliva as well as astringency feeling. Although compositions of expectorated and scraped saliva correlated between them ($R=0.899$, $p<0.05$), polyphenols were accumulated in the expectorated saliva significantly more ($p=0.031$). Retained polyphenols were correlated with astringency sensory perception ($R=0.925$, $p<0.05$), but no correlation was found with salivary proteins. These findings assessed the astringency build-up effect during wine tasting due to polyphenols accumulation in saliva, remarking the importance of the adequate PC selection.

P 12

Eating capability and saliva rheology investigationi among Chinese consumers

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Oral physiologial properties and saliva secretion play an important role in eating and oral processing of food. Biting force, tongue muscle strength are the two of such key oral physiological features. In this study, 27 healthy Chinese adults (aged from 20 to 70 years) were recruited for the study. The bite force, tongue strength, oral volume and salivary flow rate were measured for each individual using previously established methods. Whole human saliva was collected both unstimulated and stimulated and assessed for its shear and extensional rheological properties. Results show that the incisor biting force is about 40 % of that of the molar teeth. The tongue muscle strength measured by IOPI technique show significant correlations with the biting force of the incisors, left and right first molar teeth respectively ($r = 0.527$, $P < 0.01$; $r = 0.636$, $P < 0.01$; $r = 0.701$, $P < 0.01$). Whole human saliva shows very high shear viscosity at low shear rate but a viscosity which is only marginally higher than that of pure water at high the shear rate (1000 s-1). Difference of shear viscosity between the unstimulated saliva and stimulated saliva is found to be significant ($P < 0.05$). The extensional viscosity of human saliva is much higher than shear viscosity, with the maximum extensional viscosity showing an exponential relationship with the shear viscosity. Compared to stimulated saliva, unstimulated saliva showed a much higher viscoelasticity in the tensile stretching. This is the first of such investigation among Chinese populations. Results will be discussed in relation to eating behaviour and diet preference of these subjects.

P 13

Saliva esterase activity during wine oral processing: inter-individual differences, effect of wine composition and impact on wine odorant esters

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Saliva enzymes might affect the metabolism of aroma compounds during food processing impacting aroma perception and consumer's preferences. Previously, using -in vitro experiments, it has been shown that saliva esterase can hydrolyze some types of carboxylic esters. In wines, esters represent a group of compounds tightly linked to pleasant fruity aromatic notes. Till know, very little research has been done on the metabolism of aroma compounds due to the oral processing during wine consumption, and the role of esterase activity on wine aroma has not unraveling yet. Besides, wine is a hydroalcoholic solution with an acidic pH, in which polyphenols represent the large group of nonvolatile chemicals. Thus, it is not clear whether saliva esterase might have an effect on wine esters in this type of matrix.

The objective of this study, was firstly to evaluate the inter-individual differences in saliva esterase activity (SEA) in a volunteer's group (n=9) determining how SEA can be modify by wine components using saliva collected after the oral exposure to synthetic wines with different composition (pH, ethanol, polyphenols, and esters). To validate these data, two wines with very different composition and spiked with a mixture of 6 carboxylic esters differing in the length of their aliphatic chain, were also used with the 9 volunteers who performed -in vivo experiments using the Spit Off Odorant Measurement Methodology (SOOM-GCMS), in order to check the relationship between SEA and the degree of ester recovered in the expectorated wine after oral rinsing with the wines. Results showed large inter-individual differences in SEA. Moreover, the highest SEA was determined after the oral exposure to synthetic wines with low pH (3,5) and it was higher when ethanol was present at 10% than 5% (v/v), suggesting that esterase activity can be relevant at typical wine consumption conditions.

(Flash Poster Presentation)

P 14

Saliva Compositions and Diet Preference among Chinese Consumers

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Saliva secretion is known to have an important effect on the oral processing of food. We speculate that salivary composition will have a direct influence on one's diet preference. This study recruited a large number of Chinese adults (27 so far, aged between 20 and 70 years old) for both unstimulated and stimulated saliva collection and composition analysis, as well as questionnaire analysis of their food preference. Saliva flow rate, pH, protein content, and enzyme activities are the main factors for saliva analysis, in which salivary amylase and lipase activities are the main salivary biochemical factors which may influence consumers' preference of carbohydrate-dominated diet or fat/oil-dominated diet. Initial results show that salivary flow rates of Chinese consumers, both unstimulated and stimulated, are in similar range reported in literature. The total protein content (mg/mL) in whole human saliva show significant correlations with salivary amylase activity (U/mL), unstimulated saliva and stimulated saliva respectively ($r = 0.539$, $P < 0.01$; $r = 0.514$, $P < 0.01$), suggesting the dominance of amylase in human saliva. When subjects were divided into young group (aged from 20 to 60 years) and young elderly group (aged from 60 to 70 years), it was found that young elderly have a higher protein content both in both unstimulated saliva and stimulated saliva ($P < 0.01$). Despite the significant increase of salivary flow rate and salivary pH value ($P < 0.01$) after stimulating, Carbonic Anhydrase Ⅵ and Cystatin SN remain unchanged. As for the effect of diet preference, preliminary results showed that subjects who have a preference of starch diet tend to have a higher amylase activity after stimulating ($P < 0.05$). The investigation is continuing for more subjects recruiting.

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Monitoring oral activity progress during cookie eating by a motion capture video system

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Eating is a physical process in which food is transformed into a bolus through mastication. The masticatory sequence includes different types of movements from first bite to swallowing. Understanding food and human factors that influence these movements is of interest when designing food with specific textures or for populations with special requirements. Electromyography and Jaw tracking systems have been used for monitoring different aspects of oral activity but both are invasive interfering in participants' "natural" eating behaviour. The present study aims to monitor the evolution of the oral movements during eating cookies using a non-invasive 3D motion capture video system. Jaw movements of sixteen subjects eating two commercial chocolate chip cookies were registered using a 3D motion capture video system Optitrack (NaturalPoint Inc., USA) with 6 infrared cameras (100 Hz). Small reflective markers were adhered in specific landmarks of the participant´s face: 4 on the forehead as reference points and 2 at both sides of the jaw. Masticatory variables such as number of oral movement cycles, duration of the oral activity, frequency, and vertical and lateral displacement were obtained. The signal registered was separated in three periods of 10 s (P1, P2 and P3) to better study the changes over different times of consumption. Frequency values decreased as time progressed and it was slightly higher for sample A (harder cookie) than sample B. Frequency values highly varied among subjects, but all of them followed the same pattern of decrease along eating process, with a slight decrease from P1 to P2 and a higher decrease from P2 to P3. This indicates that after 20 s subjects started to finish mastication and rhythmic chewing movements turned into clearance and swallowing movements. Vertical displacement increased and lateral displacement decreased from the first to the second period, they varied among subject but no differences were detected between samples.

P 16

Influence of sucking habits on chewing aspects of preschool children

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Whereas breastfeeding has a favorable effect on the development of the stomatognathic system, bottle-feeding and pacifier use can produce different functional stimuli, which may impair oral motor function. Thus, the aim was to assess the impact of sucking habits (pacifier and bottle-feeding) on aspects of masticatory system of young children. The sample was comprised by 58 children from public kindergartens of Piracicaba (Brazil), aged 3-4 years, divided into two groups matched for age and sex: experimental group (GE), consisting of 29 children with sucking habits (pacifier and bottle-feeding), and a control group (GC), consisting of 29 children without sucking habits and with normal occlusion. The maximum unilateral bite force and labial pressure were assessed using an age-specific digital gnatodynamometer and the Iowa Oral Performance Instrument, respectively. The masticatory function was examined using a validated protocol, the Mastication Observation and Evaluation (MOE), by which the mastication of a test-food (Cream Cracker Tostines, Nestlé□) was examined and scored using video recordings by two blinded and trained Speech therapists. The following aspects were examined: tongue protrusion, lateral tongue movement, squashing or sucking movement, jaw movement, chewing duration, loss of food or saliva, number of swallows, fluency/coordination. Labial pressure did not differ between groups (GE median=4; GC median=5 kPa; p=0.581), while maximum bite force showed a significant difference between children with (median=221.4 N) and without sucking habits (median=261.7 N; p=0.049; Mann Whitney test). MOE total score did not differ between groups (p=0.359), but it showed positive correlation with bite force in GE (rho=0.39; p=0.037) and GC (rho=0.44; p=0.018). Scores for chewing time was lower in children with sucking habits (GE median=3.5; GC median=4; p=0.039; Mann Whitney test). Some aspects of masticatory function may differ in children with sucking habits when compared to controls, which denotes the importance of prevention, early intervention and follow-up treatment.

P 17

Differentiation of eating behaviors by the aspect of masseter and supra-hyoid muscles

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Introduction The elderly people with disorders of mastication and swallowing are often provided soft food, like jelly or puree. Previously, it was reported that people did not chew with teeth but squeeze with their tongue while eating semi-solid foods. Though the behavior during food oral processing is important for choking prevention, it is difficult to differentiate eating behaviors by only visual observation. This study aimed to clarify the difference in electro-myographic (EMG) activities of the masseter muscle and supra-hyoid muscles between chewing and squeezing.

Materials and Methods Eight healthy male subjects participated in the study. Four kinds of gels were prepared i.e. two kinds of hardness and deformation as test samples. The subjects were instructed to eat 5ml of gels three ways; 1. not to chew but to squeeze by their tongue, 2. to chew with their teeth, 3. to eat freely. The electromyographic activities of the masseter and supra-hyoid muscles were recorded during eating whole time. For the identification of behavior during free ingestion, videofluorography was also recorded. The gradient of correlation of EMG activities of masseter and supra-hyoid muscles during first stroke was calculated.

Results and Discussion The masseter and supra-hyoid muscles were active at almost same time during squeezing gels with their tongue. On the other hand, the masseter was active after supra-hyoid muscles during chewing. Additionally, the gradient of correlation between masseter and supra-hyoid muscles during chewing was negative whereas that during squeezing was positive. Furthermore, by using the ROC curve, the cutoff value of the gradient for differentiating behaviours was 0.092. The sensitivity and specificity of the cutoff value was 95.3% and 98.4% respectively from free ingestion trials.

Conclusion These results suggested that the aspect of muscle activities was different among the way of oral processing and the gradient was useful for differentiating ingestion behaviors.

P 18

Masticatory behavior and taste attitude evaluation of young subjects with different anthropometric status

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The reduction of food particles and taste perception are dependent on a complex multifactorial process. The objective was to compare chewing aspects and taste attitude between young subjects of both sexes with normal-weight and excess body weight. The subjects (n=231; 14-17 years) were classified according to the reference data Body mass index-for-age and sex. The following aspects of masticatory and taste behavior were examined: chewing time/frequency, masticatory performance (by means of color changeable chewing gum), the frequency/intensity of difficulty in chewing different types of foods and taste attitude (using the Health and Taste Attitude Scale in Portuguese). Data were analyzed using normality test, Pearson and Spearman correlation tests and Two-way ANOVA. Groups did not differ in the frequency/intensity of chewing difficulties, although the time spent to chew a test food was higher among females ($p<0.000$; power=1.0), with no interaction of anthropometric status. Males showed better masticatory performance ($p=0.001$; power=0.918). Significant correlations were found between chewing difficulties and masticatory performance (rho= -.17; $p=0.012$) and between chewing time and masticatory performance (r= -.25; $p=0.000$). Females scored higher on the Health and Taste Attitude Scale and, specifically, on Craving for Sweet foods subscale; no difference was observed between groups of anthropometric status. Conclusions. The present findings support the differences between sexes in many masticatory and taste aspects, which should be taken into consideration when evaluating the physiology and therapy outcomes.

P 19A

Tongue motor bio-mechanics in swallowing; non-invasive evaluation of tongue kinetics and pressure generation against hard palate

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Introduction: The tongue plays an important role in swallowing by generating the contacting pressure against hard palate. We constructed the simultaneous recording system of tongue kinetics and it's pressure generation by electromagnetic articulography (EMA) and ultra thin intra-oral sensor for investigating tongue motor bio-mechanics of swallowing.

Materials and Methods: Subjects were four young healthy males. Two EMA sensors for motion capture were attached to the anterior and posterior part of the tongue and an ultra-thin sensor sheet for tongue pressure with five sensors was attached to the hard palate. The tasks were to swallow 3ml of water in two types of swallowing manner; tipper swallow (water was held on the tongue) and dipper swallow (water was held on the floor of mouth). The tongue pressure with EMA and without EMA was measured to investigate the influence of the EMA sensors. Tongue movement trajectories were analyzed based on the characterized time points. Then sequential relationship between the onset and offset time of tongue pressure and the time points for EMA were evaluated.

Results& Discussion: EMA sensors attached on the tongue didn’t influenced on tongue pressure production. Tipper and dipper swallows showed different movement trajectories. Before the tongue pressure generation, the posterior EMA sensor separated from the palate once and then touched again, while the anterior EMA sensor remained only in one contact. Tongue pressure generated when the posterior sensor touched to the palate again and disappeared before the tongue returned a resting position. Temporal relevance was observed between the onset and offset time of tongue pressure and the time points for EMA with Intra-class correlation coefficient.

Conclusion: These results showed the sequential pattern of tongue kinetics for generating swallowing pressure on the palate. Further study about the impact of bolus texture on this pattern will be conducted.

P 19B

Can the acuity of oral texture perception be evaluated using simple oral sensory tests?

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Oral somatosensation provides a functional basis for perception of food in the mouth; however, few studies have investigated whether the ability to perceive the mechanical properties of food can be evaluated using various oral sensory testing methods. The aim of this study was to investigate the relationship between the results of oral sensory testing and the acuity of oral texture perception using oral discrimination testing of foods with different mechanical properties. The test foods used were an aqueous microcrystalline cellulose suspension, agar gel, and xanthan gum solution with various constituent concentrations. We investigated the minimum difference in concentrations (MDC) that subjects could discriminate. We measured the static two-point discrimination threshold on the anterior dorsum of the tongue in 11 healthy adults aged 25–39 years. The tactile sensory threshold in the same area was also measured using the Semmes–Weinstein monofilament test. The threshold for sensation of graininess was measured as the lowest concentration of an aqueous suspension containing microcrystalline cellulose at which particles were recognizable. No significant correlations were found between any of the two thresholds. None of the thresholds for any of the oral sensory tests correlated significantly with the MDC. However, the MDC of the constituents correlated significantly with each other. When the MDC of each constituent was graded from 1 (lowest) to 4 (highest) according to its distribution between the subjects, the total number of points for 6 subjects whose results for at least one of the three oral sensory tests were in the bottom quartile was significantly lower than that of other 5 subjects ($p=0.0055$). The ability to detect a modest difference in food texture cannot be evaluated using simple oral sensory tests because of the complex integrated nature of perception of food texture.

Theme:

3 Food Texture During Consumption

Posters

P 20

Oral processing behavior of drinkable, spoonable and chewable foods is primarily determined by rheological and mechanical food properties

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Food oral processing plays a key role in sensory perception, consumer acceptance and food intake. However, little is known about the influence of foods' physical properties on oral processing behaviour. Therefore, the primary objective of this study was to investigate the relationship of rheological and mechanical properties with oral processing behaviour of liquids (drinkable), semi-solids (spoonable), and solids (chewable) foods. Additionally, the influence of liking, frequency of consumption, and familiarity on oral processing behaviour was analysed. Rheological and mechanical properties of 18 commercially available foods were quantified, and 61 participants were video recorded while consuming these foods. After, participants evaluated products' liking, familiarity, and frequency of consumption using questionnaires. The video recordings were analysed to extract parameters describing oral processing behaviour such as bite size, consumption time, eating rate, number of swallows, number of chews, cycle duration, and chewing rate were extracted. The results of this study showed that consumers adapted their oral processing behaviour with respect to bite size, consumption time, and eating rate to the rheological and mechanical properties of liquid, semi-solid and solid foods. Nevertheless, chewing rate and chewing cycle duration of solid foods were not influenced by mechanical properties and remained relatively constant. Liking, familiarity, and consumption frequency showed to impact oral processing behaviour, although to a lower degree than the food product. Therefore, we conclude that oral processing behaviour of liquid, semi-solid and solid foods is largely determined by their rheological and mechanical properties.

P 21

Structure Breakdown during oral processing of chocolate

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Aerated chocolate products are popular consumer items associated with positive textural and sensory attributes. Among other microstructural features such as cocoa solids, milk and sugar particles, aerated chocolate consists of bubbles as well. Interaction between bubbles and particles occur during the structure build-up and structure breakdown process and therefore it needs to be investigated. Therefore, a multidisciplinary approach needs to be taken to help predict how microbubbles impact on the rheological, thermal and lubrication processes through progressive structure breakdown upon mechanical and thermal loads in the mouth. However, the effect of the aerated microstructure on the chocolate's behaviour during both industrial and oral processes is a very complex research field. During oral processing, food first fractures into particles, which interact with saliva to form a bolus, which is then swallowed. During this process, mechanical and thermal loads are experienced whilst the effect of the contact with the oral cavity is also crucial in determining the consumer's taste experience. Chocolate changes phase as it melts further complicating the behaviour. In addition, saliva also has a chemical degradation effect due to the enzymatic action. Though the main focus is on oral processing, the effect of aeration on industrial processing or manufacturing of chocolate cannot be neglected. Specifically, the effect of bubbles on the thermal properties of the chocolate is to be determined such that manufacturing can be controlled to ensure that chocolate will have the desirable textural and sensorial attributes.

P 22

A "Mouthfeel wheel" terminology for communicating the mouthfeel attributes of medical nutrition products (MNP)

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Product texture and mouthfeel contribute significantly to product perception and appreciation. For medical nutrition products (MNP) mouthfeel also contributes to both swallowing efficiency and safety, therefore impacting the nutrition and fluid intake of individuals in need of adapted textures (e.g. dysphagia patients). The need for international terminologies in a medical context has been expressed through several initiatives. Main reason for this was the inconsistency in mouthfeel terminology usage per country and care provider, which is especially important for preparing and selecting a safe and acceptable MNP for specific individuals. However, typical mouthfeel language is not specific for MNP, making it challenging to develop and communicate about optimal products for individuals in need of adapted textures. Therefore, the objective of the current study was to developed a hierarchically structured vocabulary of mouthfeel attributes elicited by MNP.

Eleven expert panelists assessed 33 MNP during a period of 3 weeks. First step was generation of the complete vocabulary in a group setting, followed by an individual Taxonomic Free Sorting (TFS) to create a hierarchical structure. Data was analyzed using Multi-Dimensional Scaling (MDS) and Agglomerative Hierarchical Clustering (AHC). The mouthfeel and texture of 33 MNP were described by a total of 51 individual attributes, which were clustered into 9 umbrella terms.

This structured vocabulary should assist expert panels, Health Care Professionals (HCP), carers, individuals in need of adapted textures (e.g. dysphagia patients), chefs, food technologists and sensory scientists in their interpretation and use of terminology related to mouthfeel of MNP. Ultimately the mouthfeel wheel should be used as a communication tool to support future product improvement and selection of MNP by HCP, with an optimal mouthfeel for individuals in need of adapted textures.

P 23

Viscosity and nutritional properties of complementary foods in Southern Africa

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Southern Africa, including South Africa, has a stunting rate above 25% for children. This has been related to poor nutrition and viscosity seems to play an important role for oral processing of porridge used as complementary food for an infant (6-24 month). The viscosity of complementary porridge has been suggested to lower than 3 Pa.s at a shear rate of about 10-50 s-1. Viscosity can determine the energy and protein density of foods. If these densities are low, it can contribute to protein-energy malnutrition. The viscosity and nutritional values in terms of protein and energy content of common commercial and indigenous complementary porridge samples found in Southern Africa were investigated.

The viscosity of 23 different complementary porridge samples for 6 – 24 months infants in Southern Africa were determined different shear rates (0.01 to 100 at 40 °C), using a rotational concentric viscometer. Protein and energy content were also measured and values compared with WHO/FAO recommendations for children 6 to 24 months old. The energy density was also calculated based on viscosity at 10 s-1 shear rate Viscosity, protein and energy content of porridge samples differed significantly ($p \leq 0,05$) with brand and solids content. Indigenous porridge samples (sorghum millet, cassava) had lower protein and energy density content relative to commercial samples based on the viscous properties. High viscoity of the indigenous porridge is due to the molecular entanglement in the system from starch biopolymers. It was also noted that some commercial products did not meet the energy and protein density as complementary foods. These indigenous and some commercial complementary foods were above the critical in-mouth viscosity limit estimate for infant swallowing (3Pa.s). Only orange flesh sweep potato as indigenous/locally available food can provide a high energy density and was below the 3Pa.s value at recommended solid content.

The results imply that indigenous porridges have very high viscosity to be used as complementary foods except for orange flesh sweet potato. Commerical complementary foods that have high viscosity can contribute to lower energy and protein intake to cause protein-energy malnutrition.

P 24

Rheology, Tribology and Sensory Properties of Low-calorie Mayonnaise Type Emulsions with Maize Starch Modified with Lipids

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This research aims to determine the effect of substituting sunflower oil with different fat replacers (maize starch (MS) + 1.5 % stearic acid (SA) and maize starch + 2 % monoglyceride (MG)) at different levels of oil replacement (50 and 80) on rheology, tribology and sensory properties of low-calorie mayonnaise type emulsion. The Bakers % calculation method was used to re-formulate existing literature formulations of mayonnaise to make provision for the addition of the fat replacers by varying only the amount of oil. Flow properties of the samples were determined at the shear rate range of 0.01 to 1000/s. The friction coefficient was determined at different entrainment speed. Textural properties were determined using a TA-XT2 texture analyser and a descriptive sensory evaluation conducted on samples using Compusense Cloud. All the sample showed shear thinning behaviour (n < 1) with their flow behaviour index (n) decreasing significantly with oil replacement levels. Mayonnaise formulated using MS + 1.5 % SA had hysteresis values comparable to that of the full-fat mayonnaise. This suggests that these samples have a better ability to rebuild their damaged structure. Mayonnaise produced with MS + 2 % MG were firmer compared with full-fat and the stearic acid containing mayonnaise. Mayonnaise formulated with the two fat replacers had lower friction coefficient at the boundary and mixed regimes compared to the full-fat mayonnaise. This denotes less friction hence samples possibly have a greater lubrication potential. Mayonnaise formulated with MS + 2 % MG at 50 and 80 % oil replacement produced low-calorie mayonnaise-type-emulsions that had sensory attributes (overall flavour, creaminess, smoothness, oiliness, mouth-coating and easy-to-swallow) comparable to that of full-fat mayonnaise. The fat replacing ability of starch with lipids is due to the formation of amylose lipid complexes (ALC). ALC in addition to the free lipids in the system seem to have some lubricity properties. The two fat-replacers successfully replaced sunflower oil in the formulation of low-calorie mayonnaise type emulsions with MS + 2 % MG having a potential of replacing sunflower oil at 50 and 80 % based on sensory attributes.

P 25

How valid is 50 s-1 for measuring viscosity of liquids?

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Currently, the oral shear rate of 50 s-1 has been adopted as the standard at which viscosity measurements for thickened liquids are measured. However, there is evidence to suggest that this shear rate might not be appropriate to model the processes in the mouth. In this two-part research, we first looked at the relations between perceived and apparent viscosity at different shear rates of two types of liquids (barium and non-barium based liquids) that had been thickened with corn starch and xanthan gum. This was followed by a second experiment where we compared the sensory and rheological properties of liquids thickened with xanthan gum, guar gum, and carboxymethyl cellulose to assess the validity of 50 s-1 as the current shear rate standard. Rheological measurements were taken with a rheometer fitted with concentric cylinder geometry at shear rates between 1 and 1000 s-1, while sensory perception of viscosity was measured by a trained panel. From the first experiment, it was apparent that media affects perceived viscosity; the best relations between perceived and apparent viscosity were observed at the approximate shear rates of 10 s-1 and 100 s-1 for non-barium and barium thickened liquids, respectively. In the second experiment, panelists perceived significant differences between thickened liquid samples that had been matched for apparent viscosity at 50 s-1. At low viscosity levels, shear rates above 50 s-1 best modeled the relations between perceived and apparent viscosity. However, no patterns were observed for liquids at medium or high viscosity levels, suggesting that instrumental shear of liquids is not a good model of oral processes. In conclusion, 50 s-1 is not an appropriate estimation of the oral shear rate, and shear rate does not account for the effect of the medium being thickened and viscosity level of liquids.

(Flash Poster Presentation)

P 26

Smooth texture perception of process cheese - Respective role of oral physiology and product characteristics on bolus formation and perception.

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For consumer, smooth texture perception is a key sensory driver of process cheese. They do not want to perceive particles in the product. Therefore during the improvement formula or process it is important to maintain this sensory property to answer the consumer's expectation. The objective of this study is to understand the respective impact of inter- individual and inter-product variability on the oral processing events during consumption of process cheeses and then on sensory perception. In the current study, 12 subjects were recruited and characterized. According to the literature, the oral physiological parameters chosen, saliva flow and viscosity, were pointed out as important in smooth texture perception. In parallel, 18 models process cheeses were designed with 2 levels of firmness (high and soft), 3 particle's qualities (little crystals, big hard particles, big soft particles) and 3 concentration of particles. Curcumin, a food grade fluorescent probe, was added to the matrices and has been used to measure the quantity of residual product in the mouth after swallowing. The food breakdown was measured by rheology and tribology analyses and quantitative descriptive analysis was used to quantify the sensory perception of the panel. The first results showed that the method used allow to discriminate food matrices and consumers according to their food bolus. Their impacts on the smooth texture perception will be discussed. This work underline the necessity to consider both subject's oral physiology and product characteristics to understand better the different mechanisms that drive in-mouth food breakdown and then their perception

P 27

Effect of mechanical properties and flavour of carrot particles added to soups on expected and perceived sensory properties and liking

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Designing palatable heterogeneous foods implies challenges that consider both food characteristics (size, mechanical properties and flavour of added particles) and consumer expectations. This study investigated the interrelationships between physical-chemical food properties and psychological variables to comprehend the effect of sensory contrast on sensory perception and acceptability of soups. Different types of carrot particles (15 w/w%) were added to creamy chicken soups. Carrot particles varying in fracture stress (40, 100, 300 kPa) and size (cubes with a side length of 3, 7, 10 mm) were used to evaluate the effect of particle addition on expected and perceived sensory properties. In addition, "fake" carrot particles (carrot flavoured agar gels) differing in carrot flavour intensity (0, 33, 66, 100%) and fracture stress (40, 100 kPa) were used to examine the role of particle flavour and mechanical properties on sensory perception. First, participants (n=70) evaluated expected liking and expected sensory perception of soups by evaluating photos of soups. Then, participants tasted the soups and evaluated perceived liking and sensory perception using the Ideal Profile method. The expected sensory properties differed between soups based on visual cues (particles varying in size): the larger the particles, the higher the expected intensities for hardness, chewiness and crunchiness. Perceived sensory properties were significantly influenced by the size and fracture stress of added carrot particles. Real and "fake" carrots did not significantly differ in overall liking probably due to the congruent and familiar appearance of the gel cubes. With increasing flavour concentration of added "fake" carrot particles, perceived carrot flavour intensity increased significantly without significantly influencing liking. Overall, soups containing medium-sized (7 mm) soft carrot particles (40 kPa) were the closest to the consumer's ideal profile. We conclude that consumer expectations and physical-chemical properties of added particles contribute significantly to the perception of complex foods.

P 28A

Preparation of easily swallowable yogurt containing Vitamin D for the elderly people

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In this research, nanostructured lipid carriers (NLC), a type of nanoparticles, were produced from mixtures of solid and spatially incompatible liquid lipids and have turned into a mature novel pharmaceutical form. This improved lipid nanocarrier has been widely applied into oral, ocular, transdermal and intravenous administration. For dermal application in this research, NLC offered advantages i.e. improved drug loading capacity, controlled drug release and drug targeting. Furthermore, NLC exhibited occlusive effects and could increase skin hydration by the joint action of some certain penetration enhancement. Mean particle size was around 500 nm and zeta potential was around -50 mV. As MCT content increased, loading efficiency increased above 75%. For all nanoparticles, a biphasic drug release pattern was found, that was drug burst release at the initial stage followed by a sustained release at a constant rate. The differential scanning calorimetry (DSC) and X-ray diffraction (XRD) analysis indicated that the incorporation of liquid lipids could interfere with the crystallization of solid lipids. Vitamin D enforced yogurt was prepared and shown to be adequate for the elderly people with Dysphagia, in which VDS, ASHA NOMS, etc, were evaluated. These results indicate that liquid lipids can be used for the encapsulation of hydrophobic functional materials (Vitamin D) and physicochemical properties of nanoparticles can be improved by controlling the processing parameters of NLC preparation, and that vitamin enforced yogurt can be used for the elderly people with swallowing problems.

P 28B

Preparation of easily chewable and swallowable texture-modified Dongchimi

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Korean traditional fermented food called kimchi, is a popular all over the world as a side dish because health benefits. Dongchimi, a type of kimchi is made by fermentation of radish with a variety of vegetables in 2-4% saltwater with approximately twice the volume of the ingredient. Radish, the main ingredient of Dongchimi is very hard material and difficult to eat for elderly people. This study was conducted to develop texture-modified Dongchimi which is safe, well-shaped, and easy to chew and swallow. As the fermentation proceeded, pH values decreased. Total acidity and lactic acid bacteria increased during fermentation. Hardness of texture-modified Dongchimi decreased significantly. Also, significant differences in hardness and shape of texture-modified Dongchimi 2 (TMD 2) were shown as compared to texture-modified Dongchimi 1 (TMD 1). Sensory evaluation showed that TMD 1 and TMD 2 were adequate for the elderly people suffering from mastication and deglutition, in which, even though TMD 2 showed higher levels in hardness, crispness, and swallowness than those of TMD1. The results indicated that texture-modified Dongchimi, which is easy to chew and swallow, will have sufficient competitiveness in food safety, food taste, and food preference.

P 29

Beyond the critical overlap mechanism of taste suppression for multi-component beverages

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It is generally reported that in random coil polysaccharide solutions, increasing polymer concentration above the critical overlap concentration (c*) results in decreased taste perception due to poor mixing efficiency with saliva in the mouth. However, these reports are commonly based on aqueous solutions of polymers so it is unknown if this phenomenon applies to more complex fluids containing protein and fat, or if taste suppression can be explained on the basis of an altered temporal profile of taste. In this study, the effects of carboxymethyl cellulose (CMC) concentration (0.15-1.50% w/w) on sensory texture and sweet taste perception (6.0% w/w sucrose) were evaluated. Zero-shear viscosity of CMC solutions ranged from 5.5 to 133 mPa·s, and the critical overlap concentration (c*) was experimentally determined to be 0.67% w/w. A significant ($p < 0.05$) reduction in sweet taste was only observed at 1.5% CMC. However, when combined with milk protein concentrate to approximate the macromolecular profile of milk, perceived sweet taste slightly increased with viscosity. Time intensity evaluations revealed a large variation in temporal sweet taste among individual panelists, with time to maximum intensity ranging from 4.8 to 33.5 s. Despite a high degree of sensory mucoadhesion, increasing CMC concentration did not significantly alter most time intensity attributes. The results indicate that the critical overlap taste suppression observed in aqueous solutions does not apply to a more complex beverage containing a combination of protein and fat.

P 29A

Impact of saliva and astringent compounds on tongue mechanical properties : an ex vivo investigation

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Astringency is a complex trigeminal sensation described as a drying-out, roughening, and puckery sensation felt in the mouth. In food, it is produced by tannins, which are abundant in beverages such as tea or red wine and in fruit such as kaki or blackthorn. This sensation is generally described as a complex tactile perception, resulting from alteration of the lubricating properties of the mucosal pellicle or saliva induced by interaction between tannins and salivary proteins.

Regarding the importance of this sensation in food acceptability, the impact of tannins on the mucosal pellicle has been the subject of numerous studies. However, these studies have been performed on synthetic surfaces, which do not reproduce correctly the tongue surface properties. In order to come closer of the human tongue properties, we decided to perform an ex vivo study on pig tongues, as pig is also omnivore. Herein, we investigate the impact of tannins on the mechanical properties of pig tongue in presence of human saliva.

After spreading human saliva over pig tongue surface, we performed 2 different mechanical analyses in order to measure (i) adhesion force, using an indentation device with a light load, and (ii) the coefficient of friction at the tongue surface. The measurements were performed before and after the addition of four different concentrations of Epigallocatechin Gallate (EgCG), a model tannin.

Our results show no significant difference for the adhesion property of the tongue between control condition and the presence of EgCG. Friction coefficient measurements indicate a higher friction coefficient in presence of EgCG. Moreover, the study reveals an effect of the concentration of EgCG. We observed a positive correlation between the friction coefficient and EgCG concentration.

This *ex vivo* study demonstrates that astringent compounds do not modify adhesion force while increase the force friction at the tongue surface.

Theme:

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Analytical ultracentrifugation as an efficient ex-vivo tool for assessing food and drug interactions with human saliva. Uncovering the mechanism for astringency in green tea and its consequences on aroma release.

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Current models describing astringency refer to a loss in salivary lubrication driven by the precipitation of proline-rich proteins, or via direct alterations of mucus within the salivary pellicle, leading to an increased friction in the oral cavity. The aim of the current study is to assess the mechanism of astringency in green tea and characterise changes in the distinctive odours released during consumption. Firstly, we propose an efficient ex-vivo method for evaluating interactions with human saliva at physiological concentrations, assessed by sedimentation velocity in the analytical ultracentrifuge (SV-AUC). Identification and quantification of protein content was determined for Unstimulated (US) and Stimulated (SS) saliva samples pooled from 6 healthy volunteers. The results showed that up to 90% consists of α-amylase and mucin, while immunoglobulin A (IgA) can make up to 10% of the total protein content in saliva. An increase in amylase concentration was observed upon stimulation (SS), which caused a decrease in the relative viscosity of saliva. Secondly, we report that astringency in green tea is caused by strong hydrogen bonding between α-amylase and flavonoid epigallocatechin 3-gallate (EGCG). This binding was shown to form large insoluble precipitates (>1 μm) contributing to an increase in the relative viscosity of the salivary bulk. Overall, this process led to a reduction in the headspace concentration of alkyl aldehydes such as pentanal and hexanal, and a significant increase in the concentration of β-ionone, benzaldehyde, dimethyl sulphide and isovaleraldehyde ($p<0.01$), while the headspace concentration of terpene alcohols such as linalool and eucalyptol remained unaffected.

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Estimation of force on human organ during oral and swallowing process using 3-dimensional computational swallowing simulator “Swallow Vision®”

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Background

The hard-soft tissue biomechanics coupled with bolus flow during oral and swallowing process are very complex and action is fast. Thus, visualizing food bolus configuration clearly using conventional medical imaging techniques is not viable. It is also difficult to measure the force on human organs during oral and swallowing process. The tongue pressure sensor or the esophageal manometry can be useful for the pressure measurement of oral and swallowing process; however it has directivity of measurement and does not obtain the force on human organ directly.

Purpose

To clarify the biomechanics of swallowing and develop easy-to-swallow food products, information of the force on the human organ is considered useful. The purpose of this study is to introduce a method for the estimation of force on human organ during oral and swallowing process coupled with food bolus configuration, position and time.
Methods The originally developed three-dimensional (3D) swallowing simulator “Swallow Vision®” implements a kinetic biomechanical and a property model of food bolus. In order to compare difference of force on each organ, the healthy young person and the mild aspirated patient model were used for numerical simulation.

Result and conclusion

For both simulation models, the magnitude and the variation in the extracted forces from each human organ, such as hard palate, soft palate, tongue, pharynx, and larynx, were discussed and explained the basis of food bolus configuration, position and time. And through the parameter studies, Swallow Vision® could find out physical properties of the food bolus not to aspirate on the mild aspirated patient model. From these results, it is considered that Swallow Vision® is helpful tool to understand the detailed biomechanics of oral and swallowing process. Moreover, the information obtained from this study might be utilized for the development of appropriate food products for dysphasia patients and the elderly.

P 32

Effect of mechanical contrast on sensory perception of heterogeneous liquid and semi-solid foods

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An increase in food palatability can often be achieved by adding texture contrast into homogeneous products. The presence of contrasting textures within a single bite is often liked since it provides an intra-oral variation of the sensory stimulus (e.g. creamy yoghurt with crunchy cereal pieces). In composite foods with embedded particles, the relation between different mechanical properties of the dispersed and continuous phase along with the sensory and hedonic perception remains unclear. This study investigated the influence of size and mechanical properties (hardness) of dispersed particles present in liquid and gelled food matrices on sensory perception and hedonic response. κ-carrageenan particles varying in size (0.8, 2.4, 4.2 mm) and hardness (fracture stress, σF, of 25, 100, 250 kPa) were added at a volume fraction of 15 w/w% to liquid, starch-based model soups and semi-solid, protein-based model gels. A Rate-All-That-Apply (RATA) method with untrained panellists (n=54) was performed to characterize the sensory profile of all samples. Additionally, they evaluated liking for all samples. Both size and hardness of the added κ-carrageenan particles significantly influenced the sensory perception of the soups and gels. The particle size mainly affected the type of descriptors selected, while the hardness of the particles determined the intensity of the selected descriptors. Soups and gels with small particles (0.8mm) were perceived mainly as gritty, whereas products with medium particles (2.4mm) were perceived mainly as beady. Increasing the particle size to 4.2mm caused a perception of lumpy and heterogeneous sensations. Attributes such as creaminess and chewiness were seen to depend on the hardness of the particles. We conclude that hardness and size of embedded heterogeneities can significantly tune the sensory product profile of model soups and gels. The approach of texture contrast could be used to design new foods with a certain desired sensory perception.

(Flash Poster Presentation)

P 33

Does rheology and oral tribology of commercial dairy colloids relate to sensory perception?

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This work investigates the relationship between rheological and tribological properties of commercial full fat and fat-free/low fat versions of liquid and soft solid colloidal systems (milk, yoghurt, soft cream cheese) with their sensory properties. Discriminative tests (n=63 untrained consumers), oscillatory measurements (strain, frequency), flow curves and tribological measurements were conducted. Oral condition was mimicked using artificial saliva containing 3 wt% mucin at 37 ○C. Untrained panelists significantly discriminated the fat-free/low fat from the full fat versions ($p < 0.01$) in all product classes, with most common verbatim used being "creamy", "sweet" for the full fat versus "watery", "sour" for the fat-free samples. Flow behaviour of both versions of milk showed overlapping trends with no significant differences identified both in absence and presence of saliva ($p > 0.05$). Full fat and fat free yoghurts had similar yielding behaviour and elastic modulus (G'), even in simulated oral conditions. However, in case of soft cream cheese, the full fat version had a moderately higher G' than the low fat counterpart. Stribeck curve analyses showed that in boundary and mixed regimes (1–100 mm s−1), both full fat yoghurt and soft cream cheese exhibited a significantly lower coefficient of friction, μ when compared to fat-free/low fat versions ($p < 0.05$), which might be attributed to the lubricating effect of the coalesced fat droplets. Surprisingly, whole and skim milks showed no significant difference in μ irrespective of the entrainment speeds ($p > 0.05$). Results suggest that sensory distinction between fat-free and full fat versions, particularly in semi-solid systems could be better predicted by surface property i.e. lubrication data, as compared to bulk rheology.

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Relating rheology and tribology of commercial dairy colloids to sensory perception.

Food and Function 2017, 8, (2), 563-573.

P 34

Low-salt recipes seasoned with grape derived-extracts and oral perception

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Grape pomace (GP) is a winery by-product composed basically of grape seeds, skin and stems. It is rich in dietary fibre and polyphenols including anthocyanins (in red GP), flavan-3-ols, flavonols, phenolic acids and stilbenes, which provides a wide variety of potential biological activities. However, from a sensory point of view, food enriched polyphenols products can result astringent in mouth due to the salivary protein-polyphenol complexation. The aim of this study is to characterize the oral sensations contributed by GP extracts (GPE) in different food matrices (tomato, white sauce and vegetable stock). For this, a descriptive panel (n=12) was trained and the food matrices not seasoned or seasoned with salt or with three different GPE (two obtained from red GP and one from white GP), were evaluated. Also, total polyphenol content (Folin-Ciocalteau method) and phenolic composition (UPLC-MS) of the GPE and the food matrices were determined to investigate any correlation between oral sensations and phenolic composition. Preliminary results showed that for the food matrices studied (tomato, white sauce and vegetable stock), the addition of the GPE increased the sensation of astringency and bitterness and significantly added wine-like flavor. Differences in salt perception between GPE-seasoned and not seasoned samples have not been found, probably due to a sensory overwhelm caused by astringency sensation. The three GPE tested led to a different spectrum of sensorial sensations in the food matrices tested, which were related to their different phenolic content, significantly higher in the red-GP extracts, rich in anthocyanins, catechins and gallic acid. This investigation allows us to deepen knowledge into the oral perception of polyphenols in food real context. Potentially, consumers may benefit from both, seasoning properties of grape-derived extracts and their preventive effects against different pathologies such as hypertension.

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Understanding the mouthfeel of plant-based beverages

Fred van de Velde *(NIZO, TIFN), Marijke Adamse, Els de Hoog*

The protein transition from animal towards plant proteins, is driven by the growth of the world's population combined with a rising standard of living. Over the last five years, this has already resulted in a 7-fold increase in product launches with a plant-based claim or notification. An important class of plant-based products are the plant-based beverages or milk analogues. Plant-based beverages are produced from a wide range of sources, including soy, rice, oat, almond and are available in both organic and regular forms. These products are generally produced starting from the whole bean or seed. They share in common a whitish, milky appearance. However, the different products show large variations in their sensory profile. These differences are not only observed for the flavour attributes, but also for the mouthfeel attributes. The mouthfeel attribute astringent showed a wide variation, ranging from almost absent in the rice drink to the top of the scale for organic soy drink. The attribute astringent is defined as a dry, puckering mouthfeel, rough ("sandpapery") sensation in the mouth. In this paper we describe the research in understanding this astringent mouthfeel in terms of tribological properties measured with a pin on disc tribometer. A clear relationship was observed between type of protein and the friction measurements. Moreover, the composition of the products in terms of protein and fat content. Although less than for astringent, large variations in creamy were observed between the plant-based drinks. The obtained formation can support the development of plant-based beverages that will contribute to the protein transition.

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Impact of Masticatory Performance and Chewing Stokes on Retro-Nasal Aroma

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Introduction

During eating, the aroma of foods is transported to the receptor of nose via velo-pharynx and perceived, i.e. "Retro-Nasal". The relationship between the dynamics of Retro-Nasal and mastication is poorly understood. The present study aimed to investigate the intensity of aroma during chewing the standardized test food for measuring masticatory performance.

Materials and Methods

Six healthy subjects participated in the study. The aroma intensity was measured over time through the nostril by an odor sensor. The gummy jelly (UHA-Mikakuto, Osaka, Japan) was used as test food for measuring masticatory performance. [Experiment I] We measured the aroma intensity during chewing the jelly until swallowing, and counted the chewing strokes to decide swallowing thresholds. [Experiment II] The subjects were instructed to chew gummy jelly certain strokes (×0.5, ×1, ×2 of swallowing thresholds, or 30 strokes) and expectorate the jelly without swallowing. The aroma intensity was measured until spit. The surface area of comminuted jelly was calculated by a fully automatic measuring device.

Results and Discussion

[Experiment I] During chewing, the aroma intensity went up 3 seconds after chewing started, and decreased after swallowing. The number of chewing strokes of swallowing threshold was 31 ± 10 times. [Experiment II] The maximum aroma intensity was significantly correlated with the surface area of comminuted jelly. The maximum intensity within the subject was significantly correlated with the number of chewing. These results suggested that high masticatory performance and a large number of chewing strokes more comminuted the jelly and increased the surface area of it, thereby raising Retro-Nasal. Furthermore, the maximum intensity at free intake was larger than that at ×1 chewing of swallowing thresholds without swallowing. Volitional suppression of swallowing might reduce Retro-Nasal.

Conclusion

These results suggested that Retro-Nasal during chewing was influenced by masticatory performance and the number of chewing strokes.

Theme:

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Food Texture Insights Through Analytical Assessment in-vivo, ex-vivo, in-vitro

Posters

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Effect of salt reduction on physical-chemical properties of sweet biscuits.

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Sodium chloride is included in cereal-based products like biscuits, as a functional ingredient as well as a flavour enhancer, and sweet biscuits have been highlighted in a survey because they are within the top ten contributors of salt intake in the UK diet (C.A.H. 2013). Thus, whilst many companies have significantly reduced sodium in many products, technical solutions for reducing sodium further are urgently required. Little is known about the effect of salt reduction on sweet biscuits and the aim of this study was to observe and understand the impact of sodium reduction on their physicochemical properties (structure, aroma release, colour, moistening…).

Standard biscuits were prepared with four levels of sodium reduction and in vitro -in vivo studies were performed: Sensory test, GC-MS (aroma quantification, SPME trapping), mechanical properties (breaking stress, confocal microscopy, X-ray CT), TGA (loss of matter during baking), colour (CIELab), moisture content and water activity.

The in vitro analyses demonstrated that sodium reduction leads to less available hydrophobic aroma compounds in the headspace and to a more breakable structure ($p \leq 0.05$). Structure monitoring showed a better development of the gluten network in salted biscuits which might lead to a better retention of the aroma in the dough during the baking process. Indeed, more salt in the dough affects gluten network formation (Tuhumury et al., 2014).

The sensory study (triangular test) with 108 panellists proved that salt reduction in these sweet matrices was significantly perceived thereby confirming the physicochemical results.

This study might help the manufacturers understand the interactions between salt, structure, and aromas in their baked food and therefore may allow them to formulate biscuits with less added salt in a more effective way while maintaining consumer liking.

P 38

Oral breakdown and perception of emulsion-filled gels: the impact of melting as opposite to particle breakdown

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Oral breakdown of emulsion-filled gels is known to depend on gels structure and rheological properties as well as on phase transitions in the mouth. This work combines results from several studies with a focus on the effect of melting of gels, as opposite to comminution into small particles, on bolus properties and sensorial perception. Emulsion filled gels containing high amounts of Gelatin were shown to melt at mouth temperature resulting in a considerably different breakdown patterns compared to other gelling systems (e.g. Agar, Locust Beam Gum, Carrageenan or Gellan gels). Particle size analysis of gels fragments from brittle gels showed that comminuted boli consisted of many small gels particles lubricated by saliva or serum release. In contrast, Gelatin gel boli consisted of fewer particles lubricated by a mixture of saliva and molten Gelatin. Image analysis of boli showed that boli from Gelatin gels had a lower value for "contrast", indicating that molten boli were homogeneous. Tribological measurements on crushed gels showed that reaching mouth temperature increased lubrication for Gelatin gels, suggesting dynamic changes in lubrication occur due to melting. Sequential profiling showed that molten boli were perceived sweeter, less grainy and creamier than comminuted boli. Moreover, attributes intensity varied more over the mastication sequence for Gelatin gels than for Agar gels, suggesting that a change in phase leads to a more dynamic evolution of perception during mastication. This was confirmed by Temporal dominance of Sensation for gels with high concentrations of gelling agents, with only 3 dominant attributes in Agar gels compared to 5 in Gelatin gels.

Overall, these results showed that melting has a positive impact on fat and sugar perception and increases dynamic changes in perception over mastication.

P 39

Authentication and Quality Fingerprinting of Honey Using Atmospheric-Pressure Chemical Ionization Mass Spectrometry (APCI-MS)

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The importance of honey quality identification has recently increased due to the illegal practices of adulteration from unscrupulous producers, traders or distributers. The traditional methods of honey authentication are very time consuming and laborious that stimulated the need for more rapid, accurate and effective analytical techniques for detecting honey adulteration. The present study presents an accurate method based on GC-MS and APCI-MS techniques to detect adulteration in honey falsified by different concentrations of sugar syrups. The fingerprints of pure and adulterated honey were collected first by GC-MS and the major volatile compounds were then identified and quantified. The key volatile compounds in the pure sugar syrup were then marked and used for scanning the honey samples in APCI-MS system in the selected ion mode. The resulting data were then modelled by multivariate analyses to detect the adulterated honeys and to quantify the amount of the adulterant in each sample. The method was examined in honeys from four different botanical origins and the results revealed that that the fusion of GC-MS and APCI-MS techniques along with relevant chmometrics analyses has a great potential in food authentication purposes.

P 40

Understanding food oral processing through rheo-tribological measurements using an in-house designed tribological cell (tribo-cell) with a rotational rheometer

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Sensory perception of many food attributes is directly linked to mechanical stimulation and friction phenomena associated with tongue-palate movement during oral processing. Whilst the former is controlled by bulk deformation and flow properties, the latter is largely determined by the changing film characteristics, i.e. composition, component distribution and thickness, of the food confined between tongue-palate surfaces.

This work investigates the rheological and tribological measurements in a simulated tongue-palate contact using a newly designed tribological-cell (Tribo-cell) attached to a rheometer. The tongue-palate contact was simulated by a silicone surface and stainless steel balls. The measurements were conducted and validated using a range of Newtonian fluids made from corn syrup with varying viscosities. It was shown that the friction behaviour of these fluids displayed different regimes of lubrication, depending on the magnitude of their viscosity (η), when plotted against sliding speeds (V). However, when the friction behaviour was replotted against the product between fluid viscosity and sliding speed (ηV), a master curve showing all regimes of Stribeck diagram was captured. These results were in good agreement with data from literature, thus, suggesting the capacity of the designed system for measuring lubrication properties under a range of sliding speed and normal load conditions. Furthermore, tests on some food samples with different levels of fat contents but similar bulk rheological properties revealed a good correlation between the friction properties and the fat content; that is the measured coefficient of friction was found to decrease with increasing product's fat content, especially in the mixed- and hydrodynamic-lubrication regimes.

Overall, this work highlights that rheo-tribology could be a valuable approach in assessing oral behaviour of food systems or their components. This tool should also allow food manufacturers and scientists to better understand food oral processing and subsequently optimise the mouthfeel of their interested liquid foods and beverages.

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Instrumental compression test of soft food gels between a soft artificial tongue and a hard plate

Kaoru Kohyama *(Food Research Institute, NARO)*

Care foods whose mechanical properties are adequately modified and can be consumed without chewing by the teeth are increasingly required in our super-aged society. Since 2012, the Japanese Ministry of Agriculture, Forestry and Fisheries promotes new care foods for dysphagic, mastication-difficulty, malnutrition and future frailty people. Smile Care Foods with a red/yellow/blue mark are being advanced so that consumers can choose suitable care foods in each state for a storefront. One of the category of Smile Care Foods (yellow 3) is tongue-mashable level.

When a soft food is compressed between the tongue and hard palate, the tongue deforms considerably and then only food is fractured. To simulate the tongue compression, artificial tongues with a similar apparent modulus to the human tongue were made with clear soft materials. Soft gels as model foods with 20 mm in diameter and 10 mm high were prepared with mixing of high- and low-acylated gellan gums [1–4]. A piece of gel was placed on an artificial tongue (50×50×10 mm), and compressed at a constant rate of 10 mm/s using a texture analyzer. Deformation profile during compression test was obtained using a video capture system. The force–deformation curves measured using the soft material were better than those obtained from a conventional test between hard plates to correlate with natural oral processing of humans. The fracture force of food between an artificial tongue and hard plate is useful for evaluation of food texture that can be mashed using the tongue.

References: 1) J. Texture Stud., 45, 354–366, 2014. 2) ibid., 47, 152–160, 2016. 3) ibid., 47, 496–503, 2016. 4) ibid., 48, 66–75, 2017.

(Flash Poster Presentation)

P 42

Effect of lubrication on the pharyngeal phase of swallowing: an in vitro study

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The design of food products for specific swallowing needs requires an in-depth understanding of food oral processing and swallowing [1]. Furthermore, understanding the formation of the post-swallow residues, their thickness, viscosity and the bolus dilution with saliva allows modulating the aroma release [2]. Conversely, incomplete bolus clearance can result in bolus aspiration in the airways. Limitations in current clinical imaging techniques do not allow for a direct measurement of the thickness of the post-swallow pharyngeal coating. The forward roll coating experiment developed by de Loubens et al. [3] was improved to assess the impact of bolus rheology and salivary flow rate on the thickness of the bolus coated on soft surfaces mimicking the pharyngeal mucosa. Several fluids with different rheological properties were used to replicate the salivary coating, while a gelatine substrate is used to mimic the elasticity of the pharyngeal mucosa. In line weight measurements and video recordings, were used to compute the average thickness of the pharyngeal coating. Results showed an increase in the pharyngeal thickness with decreasing bolus viscosity followed by an increased rate of bolus dilution with saliva. The latter is consistent with the reduction of aroma release peaks previously reported [2]. The time required for complete bolus clearance was observed to depend on the lubricant rheological properties. Finally, a slight decrease in the thickness of coating was observed at higher simulated peristalsis speed. These findings shed further light on how the bolus rheology, lubrication and tissue deformability affect post swallow residue thickness.

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P 43

Oral Processing Physiology Assessment of Texture-Designed Food in Young and Old adults

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Hardness play a critical role in food avoidance in older adults, which can contribute malnutrition in this growing population. To understand the oral processing physiology during consumption of the hardness-designed food as well as to find the difference by ages, we measured indicators of chewing and swallowing process and compared them between young adults (25.0±2.5 y, n=20) and old adults(75.5±5.6 y, n=40) using surface-electromyograph (s-EMG) and video-fluoroscopic swallowing study (VFSS). Soy based-desgined food has four levels of hardness as about 5x103, 2x104, 5x104 and 5x105 N/m2 , respectively. Results show that masseter muscles's average cotraction value(ACV), peak amplitude value(PAV), total muscle activity(TMA) were reduced by the decrease of the hardness in all subjects($p<0.05$). PAV was higher in old group compared to young group($p<0.05$) in the level of 2 to 4, although no differences were observed in the level of 1. However, TMA was significantly different in the level of 4 between groups ($p<0.05$). ACV was not different by ages. Chewing parameters were tended to be the higher in old group than young group. Amomg swallowing parameters, valleculae aggregation time (VAT) and Total duration was faster in old adults than young adults. oral processing time in oral cavity (OPT) and post-faucial aggregation time (PFAT) was significantly different by ages but only in level 1. In conclusion, oral processing physiology of hardness-desgined food can be determined by analytical measurement of chewing and swallowing properties. Old adults's difficulties of oral processing abilities can be improved by the texture designed food.

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Using tribology to access mouthfeel attributes

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The principle aim of this current work is to illustrate the benefits of tribological testing towards characterizing and understanding certain aspects and attributes of food during its journey in the human oral cavity. While mechanical, textural, and rheological testing methods are established in the field of food sciences, tribology only started gaining traction over the past decade or so. One of the reasons for this is that the traditional analysis methods could not offer insights into certain mouthfeel-dominated attributes such as stickiness, braking, etc. This study focusses on the use of extended Stribeck curves to characterize the tribological behavior of selected food samples, such as milk and milk based products, chocolates, soft drinks, etc. These extended Stribeck curves are essentially plots depicting frictional resistance of the system as a function of sliding velocity. Model-scale tests were carried out on an MCR Tribometer with a ball-on-three-pins test configuration. Here, a glass ball is made to slide against three polydimethylsiloxane (PDMS) pins with the food sample as a lubricant in between. The results showed that a correlation between the frictional behavior of food samples and certain mouthfeel attributes can be established through systematic and directed approach. In addition to this, the behavior of individual curves, such as their limiting friction, slope before and after the onset of macroscopic motion, the occurrence of stick-slip events, etc., can offer valuable information about the characteristics of the sample. This study also covers some of the complications involved in running tribological tests on food samples and ways to overcome the same.

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Evaluation of food tribology parameters for better characterization of friction-related texture attributes

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Tribology is a relatively new science for the instrumental analysis of friction-related texture attributes such as creamy, smooth, mouthcoating, powdery and astringent. This is why food tribometry needs further development for better reproducibility and discrimination of food samples of the same kind with small but significant sensory differences. The technique can be improved via the optimization of test settings and contact partners mimicking oral conditions, but also by the optimization of data analysis. This study evaluates the extraction of parameters from Stribeck curves.

Dairy matrices were measured between a rough glass ball and three polydimethylsiloxane (PDMS) pins using a T-PTD tribocell mounted on a MCR rheometer from Anton Paar, with a controlled normal load on the pins of 0.47 N at 30°C. Stribeck curves were obtained by measuring the friction coefficient (sliding force divided by the normal load) for different sliding velocities from 1· 〖10〗 ^(-5) mm/s to 100 mm/s. For each sample newly introduced in the test interstice, three Stribeck curves were measured in a row with 2 min relaxation time between each measurement. Parameters such as the main maxima and minima of the friction coefficient were extracted to approximate different friction behaviours such as the boundary, the mixed and the hydrodynamic regimes. Inspired by texture profile analysis (TPA), the ratios of parameters extracted from the first and second Stribeck curves were also calculated to evaluate the possible evolution of the food sample while being sheared twice. The result would correspond to an elasticity term influenced by a loss of structure, a phase separation or fat and particle coating phenomena. Similar phenomena may be also observed after swallowing a food sample and continuing to rub the tongue against the palate, producing a particular textural after-feel.

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alidation of compliant surface tribology setup and feasibility studies with real food systems

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Compliant surfaces provide low contact pressures formed by easily deformable bodies unlike hard-hard, hard-soft contact and thus can more closely mimic oral conditions. The tribological properties between the compliant surfaces influence how the object is perceived. The aim of the study was to validate and develop a method for in-vitro oral friction using a ball-on-disk (3-point contact) geometry. Tongue-palate purely sliding friction was mimicked by a PDMS elastomer ball and disc, respectively, with different surface roughness. The lubrication properties of a series of glycerol concentrations in water were tested with a ball-on-disc compliant geometry with viscosities in the range of 1.38 Pa.s and 38 Pa.s. The effect of viscosity, surface load and surface roughness was investigated by studying the deviation from the master curve. Real food systems were also tested with the geometry to test the feasibility of the test configuration. The test configuration is used to test thin-film related sensory attributes related to food systems such as smoothness, astringency, sweet-after taste, etc. with few additional simple fittings and attachments. This design is capable of conducting friction/lubrication measurements over a wide range of sliding speeds (0.01-40 mm/s) and at any chosen surface load. The setup is convenient to operate and easy to set controlled experimental conditions (e.g. sliding speed, surface load, temperature, etc).

Theme:

6 Impact of Food Oral Processing on Health Benefits

Posters

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Salivary Cathepsin L Content Differs between Breastfed and Formula-fed Human Infants

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Objectives: We have previously reported that levels of cystatins (protease inhibitors) in human infants' saliva were positively correlated to the duration of exposure to solid foods. This work aimed to further document proteolysis-related changes induced by a diet shift in infants, taking into account early nutrition. Methods: Saliva was collected from 18 infants (8 breastfed for at least 5 weeks, 10 formula-fed) at four different times: when infants were 3-month-old, two weeks before the parents intended to start complementary feeding (CF), and one and two weeks after the start of CF. Protein content was assessed by the Bradford method. Proteolytic activity was measured using a Pierce™ Fluorescent Protease Assay Kit based on recording lysis of fluorescein-labeled casein. The cysteine protease cathepsin L and its salivary inhibitors S-type cystatins were semi-quantified by Western Blotting. The differences between the groups (breastfed vs formula-fed, before vs after CF) were tested by Students tests. Results: Although the study was performed on a limited number of subjects, it revealed that saliva protein content was higher in formula-fed infants (0.42mg.ml-1 vs 0.31 mg.ml-1; p=0.05). The same observation was made for cathepsin levels (66 UA vs 33 UA; p=0.017), but cystatins' levels and proteolytic activity were not significantly different between the two groups. In addition, neither proteolytic activity nor levels of cathepsin L or S-type cystatins were significantly changed after one or two weeks of exposure to solid foods, regardless of the type of milk received in the first weeks of life. Conclusion: Salivary cathepsin L Content was higher in formula-fed infants. Consequences of early nutrition on proteolysis in the oral cavity deserve further attention, especially in the context where lactoferrin (a cathepsin inhibitor) is much more abundant in human milk compared to bovine milk and formula.

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The extent of oral processing determines the nutritional value of bread: an in vitro investigation

Jing Gao *(National University of Singapore), Weibiao Zhou (National University of Singapore)*

Food structure plays an important role in its digestion. As the first step of digestion, chewing determines how substantially food structure is disintegrated and subsequently, the rate of enzymatic digestion, release and absorption of macronutrients and micronutrients from food matrix. This study investigated the relation between the extent of oral processing and the kinetics of starch digestion, using bread as an example. Bread samples were artificially chewed to various extended using cutting and pestle method. The level of 'oral processing' was quantified as the size of bolus particles and amount of artificial saliva absorbed. Obtained boluses were subjected to the in vitro digestion that contained both gastric and intestinal phases. The kinetics of glucose release from the digesta were followed over a time course of 3-hour digestion. Results showed that both particle size and saliva amount played an important role in bread digestion during gastrointestinal digestion. This also implies that people response differently to the same food might be partially attributed to the different extend they orally processed their food. Results of this study also demonstrated that the oral stage of conventional in vitro digestion protocol should be revisited and carefully design for different types of products to incorporate and reflect the differences in extend of oral processing observed in population.

(Flash Poster Presentation)

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Evaluation of appetite during the milk-feeding period and nutritional status in early childhood

Maria Beatriz Duarte Gavião *(University of Campinas), Rosa Luz Abuhadba Moscoso (University of Campinas)*

The increasing trend of overweight and childhood obesity in recent decades has led to a greater interest in researching behavioral predictors that could influence childhood obesity in an obesogenic environment. In that sense, the influences of appetite characteristics during exclusive breastfeeding have received special attention. Objectives: (1) To evaluate the possible association of infant appetite in the exclusive milk-feeding period and nutritional status; (2) To observe associations of exclusive breastfeeding and socio-demographic factors with nutritional status in early infancy. Methods: Characteristics of infant appetite was evaluated by applying the Baby Eating Behavior Questionnaire (BEBQ - retrospective version) in 194 children aged 30.48 months (SD=6.61 months). The psychometric instrument was adapted in a group of 20 mothers/guardians, being that 85% of them understood all the questions. Anthropometric variables were measured in schools according to the World Health Organization (WHO) criteria. Socio-demographic data, natal history, postnatal care, eating habits and breastfeeding features were provided by mothers/guardians. The t test, Spearman coefficient and logistic regression models were applied. Results: General appetite was positively correlated with nutritional status ($p = 0.025$; $rs = 0.16$). There was no significant correlation between "Enjoyment of food", "Food responsiveness", "Satiety responsiveness", "Slowness in eating" and nutritional status ($p>0.05$). Sociodemographic characteristics and duration of exclusive breastfeeding were not associated with nutritional status ($p>0.05$). Conclusions: The infant appetite during exclusive milk-feeding was positively correlated with the nutritional status in children. Association between sociodemographic variables and nutritional status was not verified. There was no association between the duration of exclusive breastfeeding with current nutritional status.

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Impact of the masticatory behavior on metabolic syndrome

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Introduction

Mastication is behavior to process the food into bolus to be swallowed. It has been widely recognized that masticatory ability is integral for healthy long life, and sufficient number of mastication during meal is recommended. However, effective method to improve "masticatory behavior" has been yet to be established due to the lack of device for measuring the number of masticatory cycles (NM). We have developed an ear-hung type device (bitescan, SHARP Co.) to monitor the daily masticatory behavior. This study aimed to clarify the relation between mastication behavior and metabolic syndrome (MetS).

Materials and Methods

Ninety-nine healthy volunteers (50 male and 49 female, 36.4 +/- 11.7y) participated in this study. The participants were asked to eat a rice ball (100g) with wearing bitescan for counting NM. Additionally, NM for a whole day was also counted. The abdominal circumference (AC), the blood glucose level, blood pressure (BP), and serum lipid were also measured. We divided the participants into two groups using Japanese criteria for MetS (positive / negative for MetS or each MetS components) and NM was compared between groups using Mann-whitney’s U test.

Results and Discussion

Seven participants were diagnosed to MetS and 12 were pre-MetS. The mean NM for rice ball and a whole day were 215 +/- 85 and 2432 +/- 1204 respectively. NM for a rice ball in pre-MetS group was significantly smaller than the non-MetS group, and NM of positive AC, BP, and serum lipid subgroup were also smaller than negative MetS component group. Furthermore, NM for a whole day of hypertension subgroup was significantly smaller than that of non-hypertension subgroup.

Conclusion

Though this study is cross sectional and other MetS relating factors should be considered, the results suggested that the mastication behavior might have relation with MetS and MetS components.

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Impact of structural properties of solid snack food matrices on salt dissolution and salt delivery during food oral processing

Katherine Hurst *(University of Nottingham), Ian D Fisk (University of Nottingham), Charfedinne Ayed (University of Nottingham)*

Salt (NaCl) is used in crisp products as a flavour enhancer, to enhance palatability and enjoyment by the consumer. During food oral processing, sodium is released from the food matrix and dissolved in the water phase of saliva. Sodium is then delivered to taste receptor cells on the surface of the tongue in order to be perceived. There is limited literature published in the area of sodium release from solid food matrices and sodium delivery during oral processing of solid foods. Therefore this study aims to develop repeatable methods to study the release of sodium into the mouth and the dissolution into a volume of water. A further objective of this study is to determine differences in the rate of salt dissolution from commercial crisp products. These findings and methods will then be used for further investigation into salt reduction strategies to be eventually implemented into food production. A number of commercial crisp products were chosen according to similar salt contents and differences in composition, structures and methods of processing (fried sliced potato vs reconstructed potato). An in vitro method was developed by measuring conductivity of a solution of water with 1g of sample suspended in the water using a plastic cage. Conductivity values were used to determine the concentration of ions released over time. An in vivo method of measuring sodium dissolution was developed by collecting saliva samples using sterile cotton swabs at 10 second intervals during food oral processing. Sodium quantification of these saliva samples were carried out using a flame photometer at a wavelength of 589nm (sodium ion specific). It is hypothesised that the dissolution of sodium is dependent upon sample structural properties for example the amount of air included in the sample. Further studies will be conducted to correlate saltiness perception using time-intensity methods..

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The Effects of aging and oral hypofunction on masticatory performance during eating of munchy food

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Objectives:

Having proper nutrition and preserving oral function are essential to prevent frailty. We invented the munchy food which has rich protein and munchy texture. In this study, we examined the effects of aging and oral hypofunction (OH) on masticatory performance during eating of the munchy food.

Methods:

Twenty healthy young and thirty-two community dwelling older individuals participated in this study. First, we measured seven oral functions (oral hygiene, oral dryness, occlusal force, tongue-lip motor function, tongue pressure, and masticatory and swallowing functions). Each function had the cut-off value for the diagnostic criteria, and the OH was defined when more than three of the seven measures above met the criteria. Then, older participants were divided into two groups: Old with OH and Old without OH. The participants ate 10g of 4 kinds of munchy foods in random order, and we measured the masseter muscle activities with the surface electromyogram (EMG). We calculated the number of chewing cycles and the mean peak value of the EMG activities till the first swallow of the feeding sequence. We tested if those data differed among three groups using Kruskal-Wallis analysis.

Results:

The number of chewing cycles tended to be higher in Old without OH than in Young group, and the difference was statistically significant for 2 of 4 foods. However, they did not differ between in Young and Old with OH groups. The mean peak value of the EMG was, in contrast, significantly lower in Old with OH than Young but not significantly different between Young and Old without OH.

Conclusions:

Our findings suggest that eating munchy food would load more masticatory work on older individuals, and if oral function is deteriorated, the munchy food would need more masseter muscle activities. Deteriorated oral functions may significant impact on the masticatory performance in older individuals.

Theme:

7 Designing Foods for Enhancing Sensory and Consumer Experience

Posters

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Effect of age, gender and ethnicity on dynamic sensory perception and bolus properties of sausages

Monica Aguayo-Mendoza *(Wageningen University, Physics and Physical Chemistry of Foods), Eduardo Martinez (Wageningen University, Physics and Physical Chemistry of Foods), Betina Piqueras-Fiszman (Wageningen University, Marketing and Consumer Behavior Group), Markus Stieger (Wageningen University, Division of Human Nutrition)*

A food bolus suitable to swallow is formed throughout oral processing. Modifications in bolus properties trigger dynamic changes in perception. Previous studies showed that consumer groups with different demographic or sociocultural conditions vary in sensory perception and oral processing behaviour. Limited knowledge is available about how variations in oral processing behaviour among different consumer groups influence bolus properties; which might explain differences in perception between consumer groups. The aim of this study was to determine the effect of age, gender and ethnicity on dynamic sensory perception and bolus properties of a hotdog sausage. Young Caucasian (22±2.8 yrs; n=21), elderly Caucasian (70.0±4.3 yrs; n=22) and young Asian (23±1.6 yrs; n=21) consumers evaluated dynamic sensory perception of a sausage using Temporal Dominance of Sensation (TDS). Expectorated boli were collected after 33, 66 and 100% of mastication time. For all boli, saliva incorporation, fat release, particle size distribution and mechanical properties were quantified. The three consumer groups perceived the sausage similarly at the beginning and end of mastication. Dynamic sensory perception differed between the three consumer groups in the middle of mastication, specifically the dominance of sensations of fattiness and dryness. Age, gender and ethnicity had a significant effect on mastication time ($p < .05$). Elderly chewed the same amount of sausage for longer time than young consumers. Females chewed longer than males and Caucasian chewed shorter than Asians. Differences in bolus properties at the middle of mastication time could not fully explain all observed differences in perception between the consumer groups. Consumers differing in age, gender and ethnicity swallowed bolus with similar properties which were obtained by the consumers adjusting their mastication time accordingly. We conclude that differences in dynamic sensory perception between the three consumer groups during the middle of mastication cannot be solely explained by differences in bolus properties.

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Oral processing and chewing mechanisms investigated using ultra-fast X-Ray tomography for two soft cereal products in the elderly

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A study has been conducted on 20 healthy elderly subjects (aged 65 and over) with poor and satisfactory dental status and variable salivary flow rate. Subjects consumed two soft cereal products: sponge-cake and brioche. Bolus viscosity, particle size and hydration ratio were characterized at three different chewing stages. Results showed that significant differences were found principally in bolus properties. For both foods, a phenomenological model of the evolution of bolus viscosity as a function of stimulated salivary flow and chewing duration was proposed. The main discrepancy between model and experimental results was attributed to the bolus granulometry, which showed different evolution depending on the product: while a reduction of particles size over the different chewing stages was observed for sponge-cake, brioche showed some degree of particle size increment which could be partially explained by particle agglomeration during oral processing. Therefore, fragmentation mechanisms were further investigated. In this purpose, the evolution of the cellular structure of the two foods was followed, using high resolution ultra-fast x-ray microtomography at the European Synchrotron Radiation Facility, under compression at high strain (<90%). The stress response of the samples was recorded at all stages and represented against the level of strain applied. Two distinct non-linear mechanical behaviors were observed: brioche showed plastic deformation, sponge-cake displayed a rather hyper-elastic behavior. The mechanical properties were calculated, including apparent Young's modulus which is known to be related to the perceived hardness. From the segmented 3D images relative density was quantified, and the granulometry of cells and walls was obtained using mathematical morphology. Once elucidated the fragmentation mechanisms, the model will be enriched in order to better relate food structure and bolus properties, and favor the design of cereal products for elderly.

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P 55

How do we educate others to understand that texture is not an absolute, rather "is in the mouth of the beholder"?

Jacqueline Beckley *(The Understanding & Insight Group LLC), Melissa Jeltema (It! Ventures LLC), Jennifer Vahalik (U&I Collaboration LLC)*

In the development of the concept of Mouth Behavior, it was found that food texture preference was tied to unconscious food choice. Observations made during qualitative research also suggested that individuals modify texture in their mouths to better match their Mouth Behavior. The origins of the current typing tool evolved out of an extensive series of research initiatives, many of them seeking an understanding of first principles of food choice. Essential to the early stage research was the use of various approaches from epistemological tradition. The mixture of qualitative formats provided observation of the different behaviors which then lend to the iterative creation of the current Mouth Behavior typing tool, JBMB®.

The creators felt it was critical to allow those who would build upon this research to experience the "voices" of the different mouth behaviors since listening to the different ways each Mouth Behavior group experiences the same food products produces clarity to the concept of "texture is in the mouth of the beholder." The design and construction of the training program provides clear explanations regarding the role that 1) deep listening to the subjects, 2) stimulus response, and 3) personal illumination of the experience of consumption of a food product creates an understanding within the individual and the listener of an experience of texture unique from classic food research approaches.

What the Mouth Behavior Immersions have demonstrated is that science- and business-based individuals approach this area of food understanding from their own perspective. Taking time to focus on a framed series of real-time experiments allows trainees to begin to understand how to incorporate a foundation of Mouth Behavior into textural studies. This evolved perspective is essential but requires an adaptation by the researcher to a more behavioral oriented approach.

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Conception of slimming drink with improved properties using a reasoned formulation approach

Emilie Descours *(ISIPCA), Hanaei Farnaz (ISIPCA), Justine Belay (ISIPCA), Nadine Vallet (ISIPCA)*

Slimming drinks are often considered too bitter and/or astringent by consumers. We have studied the possibility of solving this problem by using the reasoned formulation. Through experimental design, sensory tests and physicochemical analysis of model products, we have established the formulation rules to improve the designing of slimming drinks. The aim was to improve their tastes, notably by acting on the intensity of aromas, sweetening power and the addition of a texturizer.

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Fat sensing in the mouth: using a combination of tribology and sensory analysis to identify potential clean label fat mouthfeel enhancers

Thelma Egan *(Kerry global technology & innovation centre), Edmund T Rolls (Oxford centre for computational neuroscience), Kate Bailey (Kerry global technology & innovation centre), J. Ben Lawlor (Kerry global technology & innovation centre)*

Consumers have increasingly demanded reduced- low- and zero-percent fat dairy products as one means of adopting healthier food choices/ lifestyles. However, from a technology viewpoint, reducing or removing fat can result in a lower total solids content, reduce lubrication properties, and result in a negative impact on sensory attributes and consumer product experience. In the past, efforts have focused on the technology aspect of fat reduction. However, in the current consumer environment, today's consumers expect more and today's challenge is not only to find suitable ingredients that mimic the mouthfeel properties of fat but to do so in a 'clean-label' way so there is no compromise on either consumer sensory (mouthfeel and pleasantness) and naturalness (clean label) experience. For dairy, milk ingredients have been used to offer clean label solutions and can act as texture enhancers. Do such solutions offer the same sensory and pleasantness properties as their full fat counterparts? Are other potential ingredients better and how should we screen for them?

The objective of the present work was to develop a screening strategy to identify potential clean label fat mouthfeel replacers for dairy applications. Specifically, we were interested in the following:

1. Develop a toolbox combining tribology and sensory analysis to identify potential clean label fat mouthfeel replacers for dairy.

2. Demonstrate the usefulness of this toolbox in screening potential ingredients in a dairy application.

Reduced fat yogurts were used in the present study. Oral texture was instrumentally assessed by both rheology (bulk thickness) and tribology (lubricating properties) with coefficient of friction captured over a Stribeck series. Sensory analysis was performed using an expert panel with over 500 hours of experience. Pleasantness scores were captured using yogurt consumers. Relationships between tribology and sensory analysis were determined. Results will be presented at the conference.

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Extensional Rheology is an Important Factor in Controlling Bolus Swallowing

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Thickened fluids are commonly used in the medical management of individuals who suffer swallowing difficulty (known as dysphagia). The aim of these is to enhance safe swallowing by reducing the risk of aspiration. There are many issues to consider in obtaining the correct consistency of fluids for patients since fluids that are too thin may enter the lungs with a potential risk of pneumonia, whilst over thickened fluids can become a choking risk. Recent studies show that rheological properties of thickened fluid (e.g. shear viscosity) affect the swallowing mechanisms, such as pharyngeal bolus transit and the duration of the opening of the upper esophageal sphincter (UES). While there is no doubt that shear rheology is a highly important factor for bolus swallowing, we always suspect that extensional properties of a food bolus could be even more relevant in controlling bolus flow, due to the stretching nature of the bolus during pharynx-pharyngeal transit. Therefore, main aim of this work is to obtain experimental evidences to prove this hypothesis. Ten samples of thickened fluids that have similar shear viscosity, but different maximum extensional viscosity and similar maximum extensional viscosity, but different shear viscosity were swallowed by ten healthy individuals. Videofluoroscopy Swallow Study (VFSS) technique was used to monitor bolus flow. The pharyngeal transit time, the amount of residue and the elongation of the bolus were calculated. It was observed that the amount of residue in the pharynx is significantly dependent on the extensional viscosity of the bolus. This shows that bolus that has lower extensional viscosity breaks more easily into multiple droplets whilst swallowing, which may cause aspiration to the individuals. This study confirms that the extensional viscosity of the bolus is an important parameter for swallowing.
Keywords: Dysphagia, Extensional viscosity, Rheology, VFSS

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Focusing on 'body': consumer understanding of the mouthfeel concept in beer and wine products

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'Body' is often described by consumers as lacking in lower alcohol beverages. However it is unclear of consumers are referring to mouthfeel sensations or rather a holistic multi-sensory concept1. A clear definition of 'body' is therefore necessary to provide direction for improvement of lower alcohol beverages, which deliver acceptable sensory experiences. The present study examined i) consumer understanding of the term 'body' and ii) sensory evaluation of commercial beers and wines to explore concept interpretation, using focus group discussions and rapid sensory profiling method, respectively. Three UK user-groups were selected comprising; beer (n=30), white wine (n=30), and red wine (n=30) consumers. Each user-group was further segmented into 3 clusters (n=10), based on product knowledge level using the Goldsmith scale2. During focus group discussions, responses to questions aimed at evaluating participants' understanding of 'body' generated insights and opinions on attributes associated with the term. Furthermore, understanding how consumers differentiate between products in relation to perceived 'body' was examined by Napping®. Each user group evaluated a dedicated sample set of either; 11 commercial beers, white wines or red wines. Key instrumental measurements (pH, titratable acidity, residual sugars, amino acids) were taken to investigate product compositional properties with consumer perceptions. Discussion transcripts were evaluated by computer-assisted content and frequency analysis (NVivo®, SQR International), showing different terms used to qualify beer and wine 'body', as well as contrast between the two beverage systems. Multi-Factor Analysis (MFA) created group maps of Napping® data, and instrumental data of product properties assisted data interpretation of factors contributing to 'body' perception. Overall, this consumer-based approach suggests 'body' is not simply a one-dimensional attribute, but rather has a number of properties important for its formation and subsequent perception. Understanding consumer perception of 'body' contributes towards maintaining sensory acceptability of alcoholic beverages, whilst reducing alcohol content to improve consumer well-being.

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Tailor made food design comprehensively linked numerical estimation, physical measurement and sensory evaluation

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Background

As for the conventional food properties design, a sensory evaluation and the trial and error are often carried out. It is difficult to find out clear relationship between result of sensory evaluation and physical properties, conventional food properties design takes lot of time and not effective.

Purpose

The aim of present study is to propose the novel food design method comprehensively linked numerical estimation taken from computer simulation, physical measurement using dynamic measurement including tribology properties and sensory evaluation for physical properties.

Methods

Based on estimated physical properties taken from the 3-dimentinal swallowing simulator "Swallow Vison®" (SV), the sample food was designed. Simulation have been carried out using mild aspiration patient model. No aspiration condition have been searched by parametric studies (viscosity was adjusted). Sensory evaluation and physical measurement by "F-bology ® analyzer" (FBA) which contained inclined plate with pseudo organ sheet were performed using the sample food estimated from SV. FBA measurements can give the meanings for the sensory evaluation, the validity of physical properties taken from SV was discussed.

Result and conclusion

On the measurement of FBA, for the sample food A which was designed by no aspiration condition for mild aspiration patient model in SV, the velocity of flown down on the pseudo organ sheet is no big difference between sample food B (aspiration have occurred in SV). Contrarily, a difference was seen between sample food A and B for the shear stress and the energy density received from food bolus. On the sensory evaluation, there are linear relationship between several FBA properties and sensory words. In this way, numerical estimation from SV, physical measurement from FBA and sensory evaluation were comprehensively linked and can discuss to appropriate and tailor made food properties for the target consumer such as patient for aspiration or elderly person.

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Does oral health of elderly people modify bolus formation, bolus characteristics and food comfortability of meat products ?

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Ageing is often accompanied by oral impairments like tooth loss or decrease saliva flow that play a key role in eating behavior. In the context of aging population, the aim of this study is 1- to understand the influence of dental status and salivary flow on the meat bolus formation and characteristics in function of meat structure, 2- to investigate the link between the food bolus properties and the food comfortability (as defined by (Vandenbergue-Descamps et al., 2017)) during meat consumption.

This was achieved by asking elderly people (n=65) with good oral health (17H, 16F, age=73±6, UFP n=8±1) or poor oral health (15H, 17F, age=75±6, UFP n=3±1) to consume 4 meat products with modified texture (minced chicken, laminated beef, shredded chicken and shredded beef). During the 4 sessions, we measured chewing frequency and bolus properties (salivary content, particles size and rheological properties). Furthermore, the subjects rated the 4 meat products using a comfortability questionnaire.

The results showed that people with good oral health have a higher masticatory frequency. They incorporate more saliva to their bolus and produce smaller particles and their bolus are less firm. They perceived the meat products as fattier, more juicy and doughy and less hard than people with poor oral health. The influence of oral health on food bolus characteristics are similar whatever the meat studied. Whatever the oral health, laminated beef is the least comfortable and the least "easy to eat" product. It gives a bolus instrumentally and sensorially harder with higher particles size, needs more saliva before swallow. The elderly perceived it more difficult to masticate, humidify, and swallow. However, it is noticeable that people with poor oral health find the meat products studied easier to consume than people with good oral health.

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Utilising sensory and consumer insights for the design of oral nutrition supplements

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Oral Nutrition Supplements (ONS) are designed to provide malnourished individuals with food and beverage products dense in nutrients. However, their intake is often lower than prescribed with taste or texture being most regularly cited as the reason. With this study we studied the sensory profile of ONS beverages with varying thickness and sweetness over consecutive, standardised sips as means of understanding product perception during consumption. In addition we investigated their impact on product liking and consequent intake. A commercially available nutritional beverage was used in this study. The product was altered in viscosity (thin and thick) with the addition of guar gum and sweetness (low and high) with the addition of sucralose. Thirty six adult consumers (average age 30 years old, mean BMI 23.7 kg/m2) were instructed to taste the product until pleasantly full and provide information on product pleasantness, liking and desire to drink. The samples were also evaluated by an expert sensory panel (N=12) via sequential profiling on 20ml sip intervals. Results showed that lower viscosity and higher sweetness resulted in higher product intake and increased product pleasantness, liking and desire to drink. Sequential profiling quantified the profile changes over consecutive sips (15) revealing an increase of the mouth drying sensation and metallic flavour while the no significant changes were observed in the remaining sensory attributes. The findings from this research could help optimise the formulation of ONS products helping increase their pleasantness and consequent intake.

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The impact of human ageing on the detection of key aroma compounds identified in a milk-based high-protein beverage.

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With ageing come changes in sensory perception which subsequently affect the experience and enjoyment of foods; one of the main changes older adult experience is impairments in their olfactory function. Olfaction is a key contributor to flavour perception, and it has been proposed that the flavour perception of foods becomes altered with ageing, leading potentially to reduced food intake and a risk of undernutrition. Although it is well documented that ageing impedes global olfactory perception, it is not known how ageing affects olfaction in relation to the detection of single aroma compounds. This study aimed to investigate how ageing influences the detection of key aroma compounds identified in a high-protein milk-based beverage. A novel Gas-Chromatography Olfactometry study was conducted which employed both healthy younger (n=6) and healthy older adults (n=6) as panellists, and a banana flavoured high-protein milk-based beverage as the food of interest. Key aroma compounds were determined by a combination of Detection Frequency and Posterior Intensity Rating methodologies. Key aroma compounds identified included Diacetyl, Isoamyl acetate, Dimethyl trisulfide and Methanethiol and the relative importance of each aroma compound differed between age groups. To further explore the differences in detection between age groups, threshold tests were conducted using the ATSM E679 standard. When compared to younger adults (n=25), Older adults (n=25) had higher detection thresholds for all aroma compounds and this difference was significant ($p \leq 0.05$) for Isoamyl acetate and Methanethiol ($p=0.02$ and $p=0.04$, respectively). To conclude, age-related impairments in olfactory detection were widespread in the subjects included in this study, and such impairments were not consistent for all the different aroma compounds. When developing foods for older adults, it is important to consider these age-related impairments to meet the specific preference deriving from an altered flavour perception.

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Measuring baby's oral motor patterns and trends with baby food snacks

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Healthy feeding development in infants includes the progression from an entirely milk based diet to one based on a variety of solids foods with varying flavor and texture. The first solid foods usually take the form of a thin, smooth, homogenous, semi-liquid food, with a gradual progression to lumpy textured foods which require early chewing motions, and finally including family foods throughout the second year of life.

The ability to eat food with textures more complex than pureed foods is dependent on both the experience of chewing and the development of coordinated oral motor skills. Research has shown the importance of introducing intermediate textures to help bridge skills to table foods. Highly dissolvable finger foods that can be self-fed by older babies often fill this gap. A method was previously developed to quantify oral motor patterns through video observation by counting the number of chews and time food remained in the mouth for each spoonful of baby food.

The objective of this research was to investigate the reapplication of this method to quantify the same variables with children eating finger foods. 151 children between the ages of 8 and 24 months old were videotaped self-feeding baby food snacks with a range of formulations and textures. Each video was coded for number of chews and residence time mouth per snack piece.

Observations showed that residence time in mouth data had significantly higher variability when compared with number of chews measure. As expected, children of younger age showed significantly higher variability for both oral motor measures compared to older children. As expected residence time in mouth and number of chews were highly correlated. Yet time in mouth decreased with each subsequent pieces of snack eaten. Lastly product formulation changes were shown to produce significant alterations in both oral motor measures.

(Flash Poster Presentation)

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Role of food oral processing as a driver of pizza liking: a new insight into the design of healthy and appreciated ultra-processed food

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In the current context of food over-consumption and junk food culture, one of the major challenges of the agrifood system is to design sustainable, healthy and appreciated foods. As sensory properties and in-mouth comfort of food contribute to the liking by consumers, it seems essential to integrate oral processing and related perceptions in the design of healthier foods.

In this context, the aim of this project was to highlight the drivers and barriers of consumer liking, with a focus on oral processing perceptions, in order to promote more sustainable and healthier foods. For that, the study is focused on pizza, which is a widely-consumed ultra-processed food, offering various compositions and numerous levers for food reformulation. 16 out of 380 pizzas representative of the French market were selected from a multicriteria mapping, based on nutritional and processing scores. These 16 pizzas were evaluated by 64 participants, all consumers of pizzas. Their appreciations were evaluated in real conditions during 16 evening meals served at the university restaurant. In parallel, a sensory profile of these pizzas was performed by a trained panel. A particular focus was given to the evaluation of food oral processing, such as difficulty to cut, to masticate and to swallow, as well as pasty or sticky perceptions. A preference mapping approach was then used to relate liking with perceptions and oral processing.

Results showed that the 16 pizzas presented wide ranges of sensory, oral processing and liking properties. Drivers and barriers of liking were identified: non-sticky and homogeneous bolus at swallowing could be considered as drivers of liking, whereas the perception of sticky and pasty bolus, or difficulty to chew and swallow were observed as limits of liking. These results were then studied in regard to quality scores, based on nutrient composition, degree of processing and environmental indicators that were determined for each of pizza. The results of this study will allow making some recommendations for producers, by integrating multiple criteria to answer to consumer expectations, while taking sustainablility and health criteria into account in the case of ultra-processed food.

(Flash Poster Presentation)

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Synthesis of biomimetic salivary pellicle: Layer-by-layer assembly of bovine submaxillary mucin and lactoferrin

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There has been an upsurge in research efforts to create biomimetic saliva with optimized lubrication properties for population suffering from oral processing difficulties, such as, Xerostomia, Dysphagia. The aim of this study was to synthesize a biomimetic salivary pellicle using salivary proteins (mucin and lactoferrin) with the view to produce an optimized system capable of producing the lubricating properties and stability of the salivary pellicle seen in-vivo.

The construction of biomimetic salivary pellicle was achieved using a layer-by-layer approach employing commercially purified bovine submaxillary mucin (BSM) (1 mg/mL) and lactoferrin (1 mg/mL) at salivary pH (pH 6.87.0). Mucins are negatively-charged large macromolecules with exposed highly hydrated glycosylated domains that contribute to the lubrication and elastic properties of saliva. Lactoferrin in saliva (isoelectric point of pH 7.5) was used as the postively charged layer. The complex real-time layer-by-layer assembling behaviour was monitored using Quartz Crystal Microbalance with Dissipation Monitoring (QCM-D) on gold sensors. Layer thickness, adsorbed mass and viscoelastic property of the assembled film were assesed. The layer structure was influenced by the relative concentrations of these salivary proteins.The lubricating properties of the multilayered biomimetic saliva was determined using nano tribometer (NTR3) and mini-traction machine (MTM) at different length scales with varying entrainment speed range (1-1000 mm/s) and load of (10 mN -12 N). Polydimethyl siloxane (PDMS) was used as the tribopairs for tribology experiments for emulating the surface of human tongue.

This study provides a promising tool to construct biomimetic salivary pellicle at physiological pH, which has potential to support with specific oral processing needs.

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Lubrication properties of ex-vivo boluses, a demonstration of correlation with sensory attributes-A scenario in reformulated chocolates

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Texture perception of chocolate is one of the key drivers for consumer liking. With increasing consumer demand for healthier snacks, the food industry is facing the strongest ever pressure to reformulate their recipes in order to meet consumers' needs. However, in most cases, reformulation will inevitably cause significant changes in texture perception. In order to understand these sensory differences, routine material property measurements of the chocolate bar itself are studied. However, this route does not tell the full story as the differences measured analytically do not always reflect the changes occurring in the mouth. As chocolate is converted into an oil in water emulsion during oral processing, its bulk properties such as rheology and particle size become less relevant, and instead its lubrication properties become more dominant, especially towards the latter stages of the chocolate eating journey. In this particular work, we have demonstrated that by studying the lubrication properties of ex-vivo chocolate boluses as well as in simulated model boluses using artificial saliva, we can better understand the texture perceptions of reformulated recipes and identify possible causes of the differences in sensory perception. Our results clearly show that samples perceived as more powdery, mouth-coating drying and less smooth show an increased friction coefficient in the mixed regime measured in ex-vivo boluses. Moreover, the simulated model boluses also gave similar results. This study demonstrated that oral lubrication data can be a powerful tool for food developers to better understand their consumer data when reformulating recipes.

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Improving texture perception in low-fat high-protein yogurts thanks to whey protein aggregates

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The demand for low-fat high-protein yogurts has increased substantially over the past years. However, manufacturing protein rich yogurts often results in rubbery mouthfeel and firmer products. Whey proteins are denatured during heating of milk leading to the formation of whey protein aggregates (WPA) able to interact with caseins during acidification. The rise of whey protein concentration in yogurts comes along with a tighter and denser protein network which can be detrimental for texture perception. The objective of this study is to produce targeted WPA from native Whey Protein Isolate (WPI) through a controlled process to obtain protein-rich yogurts with satisfying texture properties. In the present study, low fat set style yogurts were prepared adding three concentrations of extra WPI or targeted WPA. Either monodisperse or polydisperse WPA populations were studied. Sensory characteristics of these 9 yogurts were assessed by free sorting by naïve panelists (n=32). Texture perception was related to rheological properties and instrumental texture measurements of yogurts. Sensory results clearly showed that the addition of WPI and WPA increased yogurt firmness. Most interestingly, it appeared that for the same concentration, the type of whey protein added had a significant impact on texture perception. Yogurts enriched in WPA were described as creamy and unctuous whereas yogurts enriched in WPI were brittle and compact. The rheological results, and in particular the flow measurement parameters confirmed this trend. Moreover, using monodisperse small WPA instead of polydisperse WPA was a way to increase yogurts' firmness while keeping unctuousness. Incorporating WPA in low-fat high-protein milks is a promising way to modulate texture perception of yogurts. This is interesting to develop fresh dairy products with special functional properties while maintaining a good sensory experience for the consumers. Further research could focus on high-protein yogurts with desirable texture properties for the elderly.

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