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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