A custom-manufactured tribometer to analyse friction between rough and lubricated biomimetic tongues and an artificial palate

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Food oral processing is a key step in food consumption, that has a substantial influence on how consumers perceive food. Advancement in understanding this process has been recently aimed at tribological investigations that focus on the behavior of surfaces in friction through thin film lubrication. Objective To mimic the conditions in the mouth, a custom-manufactured tribological setup was employed to investigate friction mechanisms occurring in presence of rough and deformable artificial tongues, under the effect of lubrication by Newtonian solutions of glycerol. Methods Tongue mimicking surfaces with modulated roughness that had asperity heights ranging from 20-150 µm mimicking those found in humans were manufactured from solutions of polyvinyl alcohol. Newtonian aqueous solutions of glycerol covering a wide range of viscosity ranging from 1 to 1400 mPa.s were used as simple food models and spread on the artificial tongues. The tribological behavior of the system was studied during shear back and forth movements where the amplitude was 10 mm; velocity: 10 mm.s-1; with the initial normal stress being set to 9 kPa. Results The signals of the ratio between tangential and normal forces were analyzed both in terms of average values and of fluctuations, over specific time periods set at the end of motion and rest steps. Consistently with the mixed lubrication regime, the average values of friction level were reported to increase when (i) the roughness of the tongue mimicking surfaces increased and when (ii) the viscosity of glycerol solutions decreased. The fluctuations of friction level that can be associated with stick-slip events were for their part generally of higher amplitude as the roughness of the surface increased. The peak spectrum frequencies related to these fluctuations mostly ranged from 10 to 20 Hz. Conclusions The study demonstrates the importance of (i) the biological relevance of tongue properties (contact areas, rigidity, and asperity heights) and (ii) the thorough analysis of force signals to better understand the complex mechanisms of friction occurring in the mouth during food consumption.