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Rheology and Swallowing of Foods

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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.