ANNUAL TRANSACTIONS OF THE NORDIC RHEOLOGY SOCIETY, VOL. 15, 2007

Rheological properties of a barium sulphate contrast medium

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ABSTRACT

Swallowing of a food can be visualized by x-ray radiography if a radiopaque contrast medium is added to the food. The rheological properties of the food are affected by the contrast medium and extensional viscosity is affected more than the shear viscosity.

INTRODUCTION

Some people experience difficulties in swallowing due to oral and/or pharyngeal dysfunctions. Treatments may include a diet containing smaller pieces which are easier to swallow or with an increased viscosity of low-viscosity liquids[1, 2]. The latter is performed to avoid the liquid entering the airways which may be harmful. The rheological behaviour of mango purée has been found to be ideal to avoid aspiration. It is palatable and well tolerated by most patients and is therefore used for x-ray visualization. Since the purée is not radiopaque barium sulphate is added. The addition of the barium sulphate, however, changes the experienced rheological properties. Sensory analysis has showed that addition of barium sulphate makes the mixture considerably more difficult to swallow and gives it a rough feel[3]. The aim of the present study was to evaluate how and to what extent the rheological characteristics of mango purée is altered by adding barium sulphate to it.

MATERIALS AND METHODS

Four foods were tested: pure mango purée, mango purée with 12.5, 25 and 37.5% (w/w) $BaSO_4$.

The extensional properties of the four foods were measured in a contraction flow device[4, 5] using an Instron 5542 (Instron Corporation, Canton, USA). The contraction flow device comprised a feeding piston, a cylindrical sample cell, and a contraction nozzle at the end. The sample cell had a temperature jacket which could be attached to a water bath with circulating water to control the temperature of the sample. The samples were measured at 20ºC which was controlled by circulating water in the jacket of the sample cell. Measurements were performed in four replicates. Input data n and K from the Power law model for shear flow were obtained from the mechanical spectra measured with a Stresstech HR rheometer (Reologica Instruments, Lund, Sweden) and used to subtract the shear stress contribution from the total measured stress. Flow curves after pre-shear were obtained using the same rheometer.

RESULTS AND DISCUSSION

The transient extensional viscosity was measured for each extension rate. The extensional viscosity was plotted as a function of extension rate for each concentration of $BaSO_4$ (Fig 1). As can be seen from the graph, all samples had a decreasing extensional viscosity with

increasing extension rate, i.e. all samples were tension thinning. The pure mango purée had the lowest extensional viscosities followed by the purée with 12.5% $BaSO_4$. For purées with 25% and 37.5% $BaSO_4$ respectively, the viscosities were almost equal.

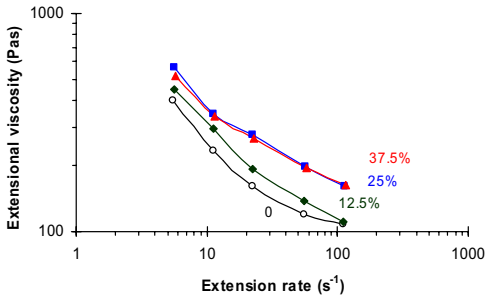

Figure 1. Extensional viscosity for mango purée with the share of $BaSO_4$ stated as percent of the total weight.

The viscosities from four flow curves were averaged for each sample and plotted against the shear rate with error bars of standard deviation (Fig 2). The shear viscosity was not as dependent on the concentration of $BaSO_4$ as the extensional viscosity was c.f. Fig 1 and Fig 2.
Our results show that addition of barium sulphate particles changes mainly the extensional rheological characteristics which coincides with the experienced sensory properties (data not shown).

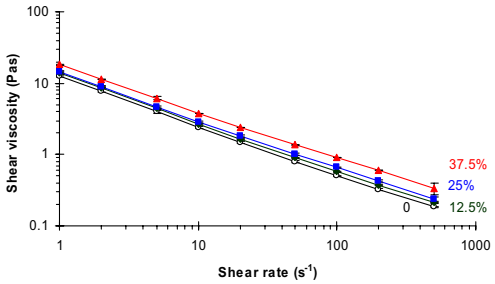

Figure 2. Flow curves in shear for mango purée with the share of $BaSO_4$ stated as percent of the total weight.

During transportation, the liquid bolus flows from the mouth into the open pharynx, passes a relatively narrow part and reaches the wider esophagus. When the bolus passes the narrow part the liquid is forced to extend and the extensional viscosity plays a more important role than the shear viscosity.

In the mouth the purée is squeezed between the tongue and the pallet which also causes a mainly extensional flow. The extensional flows during transportation could explain the strong correlation between experienced sensory properties and extensional viscosity.

CONCLUSIONS

The extensional viscosity showed larger differences with amount of added barium sulphate to mango purée as well as stronger correlation with experienced sensory properties than the shear viscosity did.

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