Rheological properties of food for patients with swallowing disorders

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ABSTRACT

Swallowing disorders require foods which are easy to swallow and do not enter the windpipe. A system of foods with texture ranging from firm pâté, over gels to viscous fluids have been characterized rheologically and sensorically. Viscometry combined with mechanical testing proved sufficient to classify the different foods and a special "texturometer" was developed.

INTRODUCTION

Swallowing disorders, or dysphagia is a general term for the dysfunction of the swallowing process involving the oral, pharyngeal (windpipe) and/or esophageal (gullet) stages of the swallowing route. It is a prevalent symptom in degenerative diseases such as stroke, dementia, Parkinson's disease and Alzheimers's disease. It also affects trauma and cancer patients having damaged skeletal or soft tissue parts in the swallowing path. Dysphagia is common in the elderly population and has been reported to effect up to 60% of the institutionalized elderly population[1]. It often leads to malnutrition and 30-60% of the patients in homes for the elderly are estimated to be malnourished.

A common diet for dysphagic patients is homogenized food. Softer foods such as vegetables are pressed through a metal strainer or homogenized in a food processor producing a viscoelastic dispersion. The texture and appearance is often less than desirable leading to lower food intake and further malnutrition. The texture is also important for the ability to swallow the food. A higher viscosity and presence of small particles helps guiding the fluid to the gullet preventing it from entering the windpipe. Less affected patients can also handle soft foods such as mashed potato, pâtés and timbales and do not really need homogenized foods.

A set of foods suitable for dysphagic patients has been developed[2]. It is divided into different classes aimed for the different degrees of dysphagia and different categories of patients. These classes are:

- Low viscosity fluids
- High viscosity fluids
- Gel foods
- Solid timbales
- Solid pâtés

Different types of foods from these classes are available commercially, mainly for institutions and hospitals[2]. The classification can also be used in homes for elderly and hospital kitchens to prepare and serve a correct diet which is easy to swallow, nutritious and at the same time appealing. The aim of this study was to rheologically and mechanically characterize the different classes and to develop an easy tool facilitating the production of dishes for dysphagic patients.

MATERIALS AND METHODS

Prefabricated foods and ingredients were provided by Findus[2] as presented in Table 1. The gels were prepared from concentrates by adding 1.5% of gelatine, heating to 80°C and cooling to 8°C. The viscous fluids were prepared from concentrate and a starch based thickener (Thick&Easy, Hormel HealthLabs, GA, USA) was added to achieve the high viscosity fluids. These were heated to 80°C while stirred and cooled to serving temperature. The serving temperature is 60°C for the warm foods and 8°C for the cold foods. The same temperatures were used for the rheological and mechanical characterization.

Table 1. Classes and types of foods investigated.

Class	Type	Meas. T [°C]
Low η fluids	Meat, vegetable, exotic fruits	60 8
High η fluids	Meat, vegetable, exotic fruits	60 8
Gel foods	Meat, vegetable,	60
Timbale	Broccoli, meat	60
Pâtés	Broccoli, meat, beans, preserved fruit	60 8

Flow curves at shear rates 1-500 s^{-1} were obtained for the fluid foods using a Stresstech HR (Reologica Instruments, Lund, Sweden). The Power Law model was fitted to extract the Power Law index n and the consistency index K.

Penetration tests with a 4.8 mm cylindrical probe was used for the viscoelastic foods in an Instron 5542 (Instron Ltd, Canton, MA, USA).

Extensional viscosity of the fluid foods was determined using Hyperbolic Contraction Flow[3].

RESULTS AND DISCUSSION

The flow curves for the fluid foods showed a Power Law index n≈0.4 for all samples as shown in Table 2. The consistency index could be used to distinguish between the classes of low viscosity and high viscosity. The high viscosity foods showed relatively high standard deviation probably depending on the temperature dependence of the thickening agent. Variations in preparation and temperature then cause the viscosity variations.

Table 2. Power Law parameters

Food	T [°C]	n	K [Pas^n]
Exotic fruit, low η	8	0.42	1.94
Exotic fruit, high η	8	0.43	8.50
Vegetable, low η	60	0.49	1.00
Vegetable, high η	60	0.34	7.61
Meat, low η	60	0.37	3.33
Meat, high η	60	0.43	12.04

The extensional viscosity showed similar results, as shown in Figure 1. The low viscosity meat fluid had unexpected high shear and extensional viscosity placing it close to the high viscosity fluids. The low viscosity vegetable and exotic fruit fluids showed a more pronounced dependence on extension rate which should have an effect especially at the relatively high extension rates present in the mouth and during swallowing.

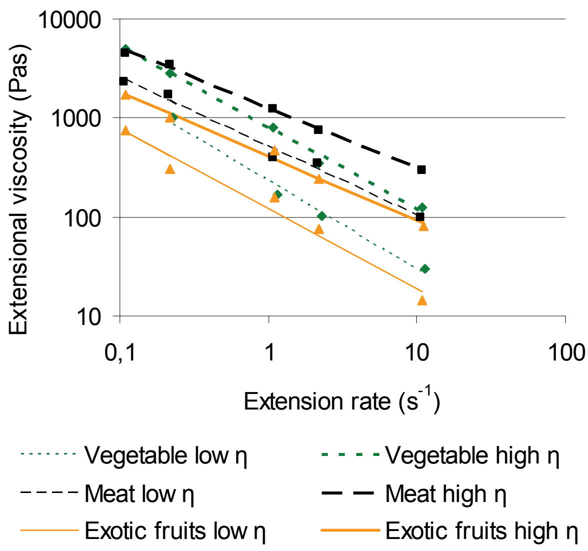

Figure 1. Extensional viscosity of the fluid foods.

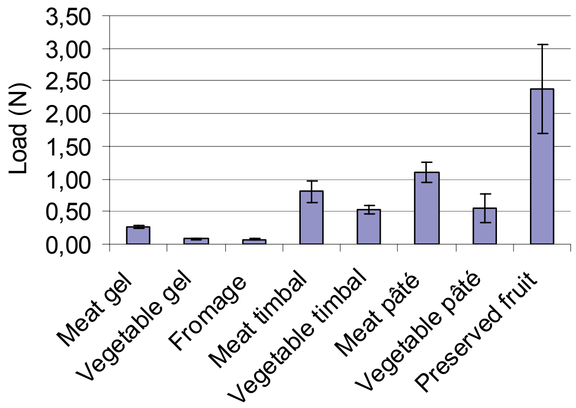

Figure 2. Penetration force for the solid foods.

The different classes of solid foods were separated by a penetration test with the penetration force increasing for the classes gel, timbale and pâté, as shown in Figure 2. Preserved fruit was included in the pâté class s and had the highest penetration force. The vegetable pâté tested was a green bean pâté which had a structure that did not keep together. Aggregates of the vegetable constituents fell apart when deformed thus causing an overall low penetration force. A similar compression test gave less distinction between the classes as compared to the penetration test (data not shown).

The different foods investigated were pre-fabricated under controlled conditions, but there is a desire to make well defined foods also in e.g. a hospital kitchen. It is important for the hospital staff to accurately classify the food produced to get the correct texture for each patient and a simple instrument is therefore needed. The instrument has to be robust and easy to use. Figure 3 shows the "SIK Texturometer" which can be used to differentiate between low viscosity and high viscosity fluids by a "falling rod" test, and between timbales and pâtés by a penetration test. For the falling rod test the cylinder is filled with 100 ml of the fluid and the inner cylinder is allowed to fall 50 mm while timed. The cut-off between low viscosity and high viscosity fluids is approximately 3 s. The two different penetration probes can be used to differentiate between timbale and pâté (thick probe) and also to test if a pâté is too strong (thin probe). If the thin probe does not penetrate a pâté it is to strong for consumption by the patients.

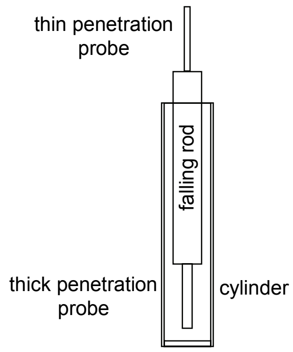

Figure 3. Sketch of the SIK Texturometer.

CONCLUSIONS

A combination of viscosity tests and penetration tests can mostly differentiate between different classes of foods for dysphagic patients. If sensory attributes such as sliminess of gel foods and some common sense is added all pre fabricated foods can be classified. A simple texturometer can be used for new dishes to accurately classify them in the existing system.

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