

RHEOLOGY OF BARIUM SULFATE SUSPENSIONS AND PRE-THICKENED BEVERAGES USED IN DIAGNOSIS AND TREATMENT OF DYSPHAGIA

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ABSTRACT:

Pre-thickened beverages and barium sulfate suspensions are used in the treatment and diagnosis of dysphagia. These liquids are labeled nectar consistency (NC), honey consistency (HC) etc. These labels are rather misleading and do not represent the actual rheological character of the liquids. We carefully investigated the rheology of these liquids to assist both in their formulation and use for dysphagic patients. Steady state flow properties, thixotropy, dynamic response, and creep recovery behavior were investigated for six beverages and two barium sulfate suspensions. All samples exhibited a shear-thinning behavior. The flow curves of all samples followed both Herschel-Bulkley and Casson models. HC barium sulfate suspension exhibited higher yield stress, σ_o , and higher storage modulus, G' , than their fluid food counterparts. In contrast, NC barium sulfate suspension had lower σ_o and G' than some of the liquid food counterparts. Frequency spectra of NC samples were similar to that of a macromolecular solution with both G' and loss modulus, G'' , increasing with frequency; whereas those of HC samples were similar to that of a gel with a little dependency of G' and G'' over frequency. Stress sweep experiments showed that the linear viscoelastic region of fluid foods and barium sulfate suspensions extended up to 1 and 10 Pa, respectively. Thus, significant differences exist in the rheological properties of both pre-thickened and videofluoroscopy fluids currently used for diagnosis and treatment of dysphagia.

ZUSAMMENFASSUNG:

Vorverdickte Getränke und Bariumsulfat-Suspensionen werden zur Behandlung und Diagnose von Dysphagie verwendet. Diese Flüssigkeiten werden als Nektarkonsistenz (NC), Honigkonsistenz (HC), etc. bezeichnet. Diese Bezeichnungen sind irreführend und geben nicht den wirklichen Charakter der Flüssigkeiten wieder. Wir untersuchten sorgfältig die Rheologie dieser Flüssigkeiten, um sowohl bei ihrer Rezeptur als auch der Anwendung bei dysphagischen Patienten mitzuwirken. Die stationären Fließeigenschaften, Thixotropie, die dynamische Antwort und das Kriecherholungsverhalten wurden von sechs Getränken und zwei Bariumsulfat-Suspensionen untersucht. Sämtliche Proben wiesen ein Scherverdünnungsverhalten auf. Die Fließkurven aller Proben folgten den Herschel-Bulkley- und Casson-Modellen. HC-Bariumsulfat-Suspensionen besaßen eine höhere Fließspannung und einen höheren Speichermodul G' als ihre flüssigen Lebensmittelgegenstände. Im Gegensatz dazu waren die Fließspannung und der Speichermodul der NC-Bariumsulfat-Suspensionen niedriger als die der Lebensmittelfluide. Die Frequenzspektren der NC-Proben waren denen einer makromolekularen Lösung ähnlich, wobei G' und der Verlustmodul G'' mit der Frequenz zunahm. Dagegen waren die Frequenzspektren der HC-Proben denen eines Gels mit einer geringen Abhängigkeit von G' und G'' über den gesamten Frequenzbereich ähnlich. Die Spannungsdurchlauf-Experimente zeigten, dass der linear-viskoelastische Bereich der flüssigen Lebensmittelsubstanzen und Bariumsulfat-Suspensionen bis zu 1 bzw. 10 Pa erweitert wurde. Daher existieren signifikante Unterschiede in den rheologischen Eigenschaften sowohl der vorverdickten als auch der Videofluoroskopie-Flüssigkeiten, die gegenwärtig für die Diagnose und Behandlung von Dysphagie benutzt werden.

RÉSUMÉ:

Les boissons pré-épaississantes et les suspensions de sulfate de baryum sont utilisées dans le traitement et le diagnostic des dysphagies. Ces liquides sont labellisés comme nectar texturant (NC), miel texturant (HC), etc. Ces labels sont plutôt trompeurs et ne représentent pas le caractère rhéologique réel des liquides. Nous avons étudié avec attention la rhéologie de ces liquides afin d'aider à leur formulation ainsi qu'à leur utilisation pour les patients dysphagiques. Les propriétés en écoulement établi, la thixotropie, la réponse dynamique et le comportement de relaxation de contrainte ont été étudiés pour six boissons et pour deux suspensions de sulfate baryum. Tous les échantillons ont présenté un comportement rhéo-amincissant. Les courbes d'écoulement de

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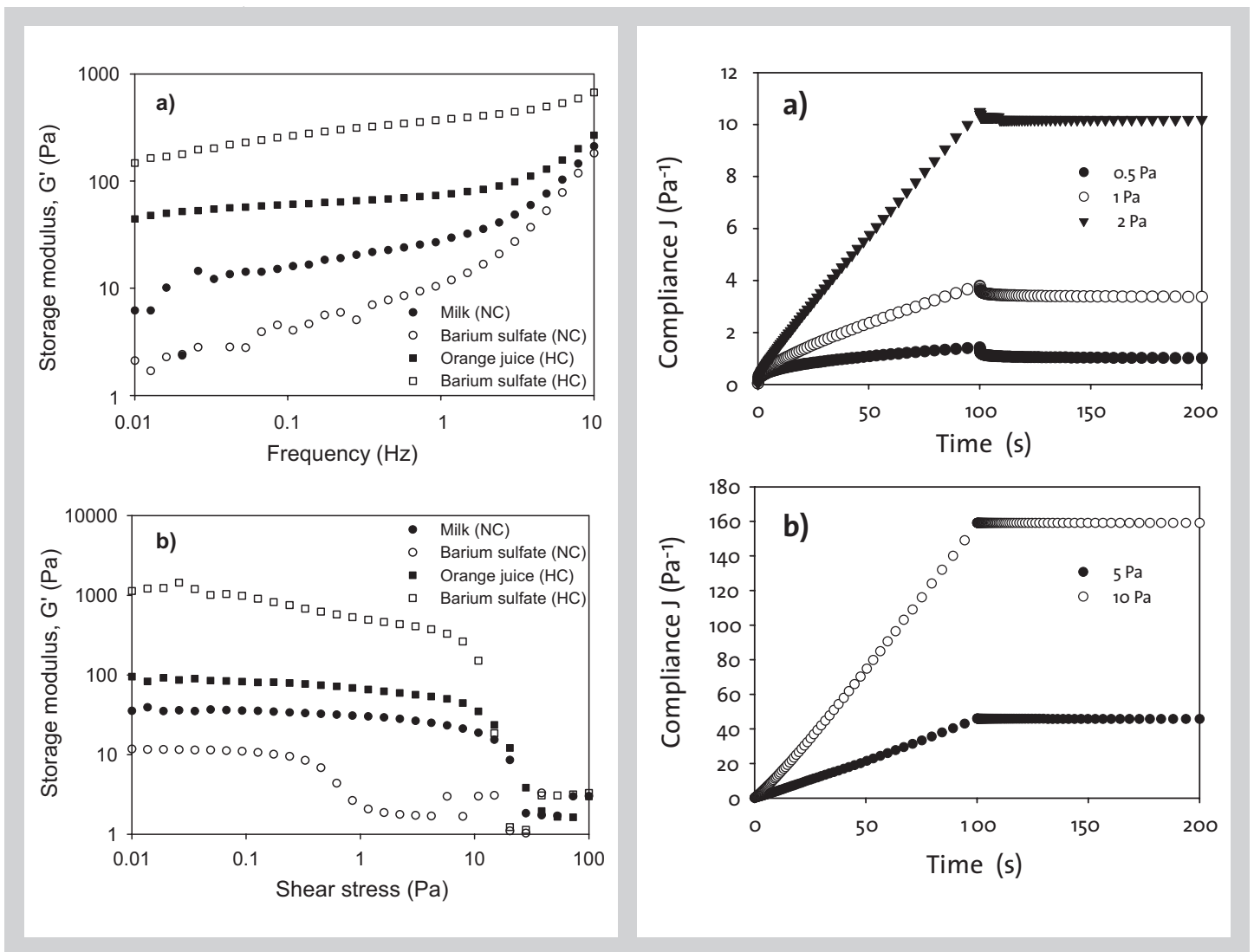


Figure 3 (left):
 a) Mechanical spectra of nectar consistency (NC) and honey consistency (HC) samples.
 b) Stress sweep data of nectar consistency (NC) and honey consistency (HC) samples.

Figure 4:
 a) Creep recovery response of thickened milk with a nectar consistency at three levels of applied stress.
 b) Creep recovery response of thickened milk with a nectar consistency at two levels of applied stress.

4 CONCLUSIONS

The rheological behavior of six pre-thickened beverages and two barium sulfate suspensions, which are used for the diagnosis and treatment of dysphagia, were measured at room temperature using a controlled-stress dynamic rheometer. All samples exhibited a shear-thinning behavior. The shear stress vs. shear rate relationships of all fluids followed both the Herschel-Bulkley and Casson models. HC barium sulfate suspension exhibited higher yield stress and higher elastic modulus than their fluid food counterparts. In contrast, NC barium sulfate suspension showed lower yield stress and lower elastic modulus than some of its liquid food counterparts. These results suggest that the ready-to-serve fluids that currently exist in the market exhibit rheological properties significantly different from those of barium sulfate suspensions used for diagnosis of dysphagia. Finally, this study describes appropriate methods for an in-depth characterization of the rheological properties of pre-thickened foods and videofluoroscopy diagnostic fluids for dysphagic patients,

and also shows that rheology can play an important role in diagnosis and treatment of dysphagia by objectively characterizing the properties of the foods most acceptable to a patient and aiding in the selection of foods that best fit his or her needs.

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