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The rheological properties of polysaccharides sequentially extracted from peony seed dreg

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ABSTRACT

The peony seed dreg polysaccharides (PSDPs) were sequentially extracted using hot buffer (HBSS), chelating agent (CHSS), dilute alkaline (DASS) and concentrated alkaline (CASS). The rheological properties of PSDPs were investigated by steady-shear and oscillatory rheological measurements. The four PSDPs fractions in solution exhibited typical non-Newtonian and shear-thinning behavior. The viscosity of HBSS was higher than the rest. While the viscosity value of all PSDPs solution decreased at acid pH (4.0) and alkaline pH (10.0), in the presence of Ca^{2+} and high temperature (90 °C), it increased in the presence of Na^{+} and following freezing. The modulus G' and G" of all PSDPs solution were increased with increasing oscillation frequency ranging between 0.01 and 100 Hz at each concentration. In all four cases, the crossover of G' and G" values decreased gradually with increasing concentration of samples.

1. Introduction

Plant polysaccharides have attracted much attention due to their multi-functionality in bioactivities that include their antioxidant, immunomodulatory, antitumor, and hypoglycemic properties [1,2]. Polysaccharides are also widely used in food industry as thickening and gelling agents due to their ability to retain water and form hydrogels [3]. These rheological properties of polysaccharides are the basis for their applications as functional food and pharmaceutical industries [4]. Rheological properties are defined as mechanical properties that result in deformation and the flow of material in the presence of a stress [5,6]. Rheological data are required for functional food product quality evaluation, engineering calculations, and process design [7]. Polysaccharides are viscoelastic materials that exhibit solid and liquid characteristics simultaneously [8]. Except for inner microstructure, the rheological behaviors of polysaccharides are affected by external factors, such as temperature, concentration, and presence of sugars or salts [9]. To the best of our knowledge, there are no reports on rheological properties of peony polysaccharides. Peonies (*Paeonia suffruticosa Andr.*), in addition to their ornamental values, are widely used in Chinese medicine [10]. For example, two bioactive components of tree peony (paeoniflorin and paeonol) are known to exhibit a variety of pharmacologic activities including, analgesic and hypnotic effects [11] and amelioration of progression of Spinocerebellar ataxia and Huntington's disease [12]. To examine the potential of peony seed dreg polysaccharides (PSDP) to be used as a new hydrocolloid source in the food industry, four defined fractions of PSDP was obtained after sequentially extraction with hot buffer (HBSS), chelating agent (CHSS), dilute alkaline (DASS) and concentrated alkaline (CASS). and then, the effects of concentration, temperature, pH and salt on rheological properties of four PSDPs were examined.

2. Materials and methods

2.1. Materials

Anhui Tongling Ruipu Peony Industry Development Co., Ltd., supplied the peony seed dregs, the byproduct of oil extraction. The dregs were dried in a DHG-9070A dry thermostatic oven (Jinghong Experimental Equipment, Shanghai, China) at 60 °C to a stable moisture content of <4%. Dry dregs were ground to fine powder

Abbreviations: PSDP, peony seed dreg polysaccharide; HBSS, hot buffer soluble solids; CHSS, chelating agent soluble solids; DASS, dilute alkaline soluble solids; CASS, concentrated alkaline soluble solids; AIS, alcohol-insoluble solids; DHR-3, discovery hybrid rheometer-3; G', storage modulus; G", loss modulus.

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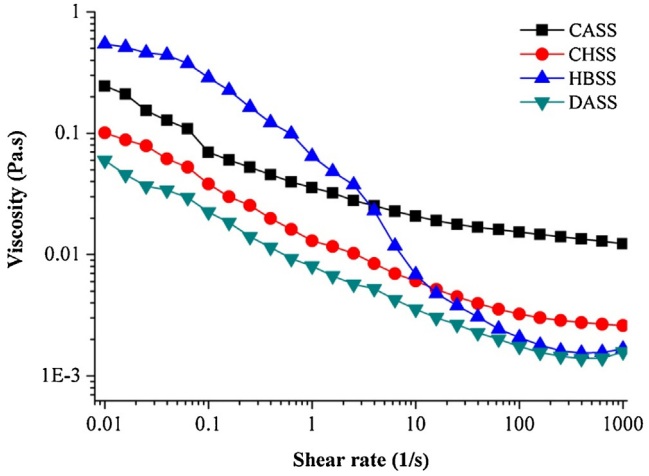

Fig. 1. Steady shear flow curves of peony seed dreg polysaccharides solutions at 1% concentration. Steady-shear rheological measurements were carried out at 20 °C.

using a TQ-2000Y grinder (Rui-he Experimental Equipment, Zhejiang, China) and the sample was stored at 4 °C.

2.2. Sequential extraction of peony seed dreg

The sequential extractions of polysaccharides from peony seed dreg were performed as described elsewhere [13]. The peony seed dreg was homogenized twice with 70% (v/v) aqueous ethanol at room temperature. After filtration, the insoluble residues were combined and washed with two volumes of chloroform/methanol (1/1, v/v) with gentle stirring for 30 min to remove low molecular weight (colored) compounds [14]. After filtration, the solids were washed with acetone and air-dried (alcohol-insoluble solids, AIS). A 20 g peony seed dreg AIS was sequentially extracted with hot buffer (HBSS), chelating agent (CHSS), diluted alkali (DASS) and concentrated alkali (CASS) to recover soluble solids [13]. After each extraction, the soluble was separated from the insoluble residue by centrifugation (10,000 rpm for 25 min). The supernatants were dialyzed, freeze-dried and stored until further analysis.

2.3. Rheological measurements

Peony seed dreg polysaccharides (PSDPs) were dispersed at 0.6–2.5% in deionized water. The solutions were placed in sealed glass vials and left overnight under continuous stirring to ensure complete solubilization [15]. Steady-shear rheological measurements were carried out at 20 °C using a Discovery Hybrid Rheometer-3 (DHR-3) (TA instruments, New Castle DE, USA) equipped with a cone-and-plate geometry (diameter 40 mm, cone angle 2°).

2.3.1. Effect of concentration on viscosity

Flow curves were determined over the range of 0.01–1000 s^{-1} at 20 °C.

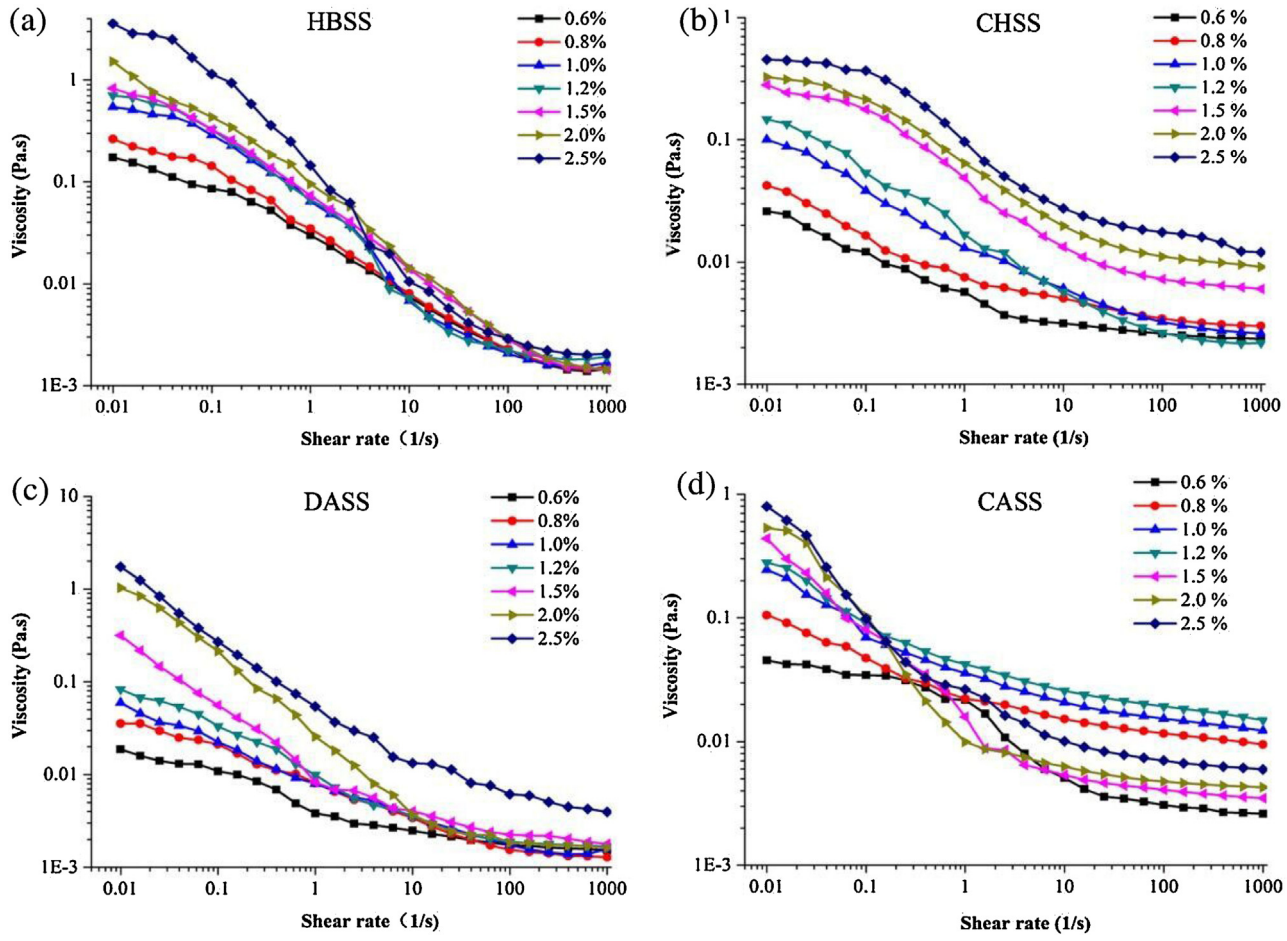

Fig. 2. Steady shear flow curves of peony seed dreg polysaccharides solution at different concentrations. Steady-shear rheological measurements were carried out at 20 °C.