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Rheological and physical properties of spray-dried mucilage obtained from *Hylocereus undatus* cladodes

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ABSTRACT

This study examines the rheological behavior of reconstituted spray-dried mucilage isolated from the cladodes of pitahaya (*Hylocereus undatus*), the effects of concentration and its relationship with physical properties were analyzed in reconstituted solutions. Drying process optimization was carried out through the surface response method, utilizing a factorial 2^3 design with three central points, in order to evaluate yield and rheological properties. The reconstituted mucilage exhibited non-Newtonian shear-thinning behavior, which adequately fit the Cross model ($R^2 > 0.95$). This dynamic response suggests a random coil configuration. The steady-shear viscosity and dynamic response are suitably correlated through the Cox–Merz rule, confirming the mucilage's stability of flow. Analysis of the physical properties of the mucilage (Tg, DTP, and particle morphology) explains the shear-thinning behavior.

1. Introduction

The selection of new sources for biopolymers requires an understanding of functional properties such as rheological and physicochemical characteristics (Chin, Chan, Yusof, Chuah, & Talib, 2009). Study of polysaccharide flow properties has contributed to identification of potential applications, development of new products, and methods for evaluating quality and stability during storage. Furthermore, identification of rheological properties has made it possible to characterize the structure of a given biopolymers and understand the changes that it undergoes as a result of preservation processes (Morris, Cutler, Ross-Murphy, Rees, & Price, 1981; Nindo, Tang, Powers, & Takhar, 2007). Mucilages and gums are heteropolysaccharides with rheological properties that are of great interest for a number of applications. The hydrocolloid characteristics of these biopolymers are the primary motivation for their utilization in the foodstuffs, environmental, cosmetic and construction industries (Sáenz, Sepúlveda, & Matsuhiro, 2004). Biological sources of mucilage that have been studied include flaxseed gum, *Alyssum homolocarpum* seed, nopal cactus (*Opuntia ficus indica*) (Koocheki, Mortazavi, Shahidi, Razavi, & Taherian, 2009; León-Martínez, Rodríguez-Ramírez, Medina-Torres, Méndez Lagunas, & Bernad-Bernad, 2011; Medina-Torres, Brito-De La Fuente, Torrestiana Sánchez, & Katthain, 2000; Wang, Li, Wang, Li, & Adhikari, 2010). The demand for hydrocolloids with a specific functionality has increased recently in the foodstuffs industry (Koocheki et al., 2009); to satisfy this demand, research on new sources of polysaccharides, such as *Hylocereus undatus*, is needed. The rheological properties of dragon fruit (*Hylocereus* spp.) purees have been studied (Liaotrakoon et al., 2011); however, the properties of mucilage isolated from the stalks of the plant have not been investigated.

Shear-thinning or pseudoplastic non-Newtonian behavior has been reported in gums and mucilages; this property depends on factors such as pH, ionic strength, and dissolved solids concentration (Koocheki et al., 2009; León-Martínez et al., 2011; Medina-Torres et al., 2000). The chemical structure of the polysaccharide and its conformation, particle size distribution, and particle shape, as well as the interactions between suspended particles, are known to affect flow behavior (Chiou & Langrish, 2007; Nindo et al., 2007).

The behavior of non-Newtonian fluids can be represented through various rheological models, including the Cross model, which describes shear-thinning behavior and includes the Newtonian zone (Chin et al., 2009; Medina-Torres et al., 2000).

The properties of viscoelastic materials, such as certain polymers, are determined via small-amplitude oscillatory tests. The elastic modulus (G'), viscous modulus (G''), and complex viscosity (η^*) provide information on the structure and molecular configuration of materials, whereas the loss tangent ($\tan\delta$) denotes the relative effects the components G' and G'' exert on viscoelastic

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