ABSTRACT

Aloe barbadensis Miller (Aloe vera) raw gel is considered to be a potent source of gums and hydrocolloids, but highly unstable, hence it is converted into dry powder form by removing excess water. Reconstituted hydrogels from partially purified powder were prepared for retaining the structural and mechanical properties of the gel or solution before drying.

The effect of prepared aqueous dispersions from Aloe vera fibrous powders viz., freeze dried (FD), dehumidified air dried (DH), and hot air dried (HA) and the non-fibrous alcohol insoluble residues (NFAIR) powders on functional and rheological properties were investigated. FTIR spectrum confirmed the presence of bioactive acetyl groups in the selected powder. Flow behavior of the dispersions at different temperatures of 30, 40, 50, and 60 °C and concentrations of 0.2, 0.4, 0.8, 1.6 and 3.2% (w/v) showed shear thinning behavior. Oscillatory analyses of concentrated dispersions were also carried out at a critical volume. Fibrous dispersions showed low critical volume (1.5 to 2.5 ml H_2O/100 mg of dm) and 1000 times higher magnitude of storage modulus (G') (12,320 to 32,043 Pa) than fresh juice (2 to 25 Pa) indicating a solid like property. On the other hand, the non-fibrous powder showed a high critical volume (10 ml H_2O/100 mg of dm) with water and crossover points ($G' = G''$ at frequency 0.80–1.0 Hz) depicting its sol–gel nature and suitability for hydrogel formation.

The effects of different methods of reconstitution such as shaking (S), combined heating-shaking (HS) and heating (H), at various concentrations (0.2-1.6%, w/v) of NFAIR powders, on gel strength and stability were studied by rheological analysis. H method was found to be suitable as compared to S and HS methods in terms of higher G' value (24-195 Pa), and disappearance of terminal zones. Further, at a fixed concentration of 1.6%, w/v the effect of heating process temperature (30-90 °C) and time (15-60 min) on viscoelastic behavior was analyzed. At 50 °C for 30 min, the G' and complex modulus (G^*) was well described by Power law ($R^2 > 0.95$) and Weak gel ($R^2 > 0.94$) models.

The effect of pH (3-7) and concentration (0.2-1.6%, w/v) on viscoelastic behavior of the reconstituted Aloe vera fractions were assessed by using Power law model ($R^2 > 0.97$ for G' and $R^2 > 0.92$ for G'' Pa) and Weak gel model ($R^2 > 0.91$ for G^*). The model fitted values viz., intercepts (G'_0, Pa.s$^{n'}$, and G''_0, Pa.s$^{n''}$), slopes (n' and n''), network strength (A_F, Pa.s$^{1/z}$) and number of networks (z) were further validated using ANOVA and response surface plots. The concentration term was found more influencing than its interaction and individual pH term towards all responses of the reconstituted Aloe vera samples. Further, the individual effects of concentration (0.2-1.6%, w/v) and pH (3-7) on the functional and morphological attributes of the Aloe vera reconstituted fractions/xerogels were evaluated using FTIR, SEM and TEM. The obtained results confirmed the participation of weak forces of interactions as well as formation of network-like pattern for attaining the reconstituted Aloe vera gel.

The effect of concentration (0.2-1.6%, w/v) and temperature (30-60 °C) were optimized for reconstituted hydrogel formation, targeting maximum intercepts (G_0' and G''_0) and minimum slope (n' and n'') values using numerical optimization technique. The optimum condition selected was 1.6%, w/v at 30 °C having higher gel strength; G'_0 (47 Pa.s$^{n'}$), G''_0 (27 Pa.s$^{n''}$) and minimum slope values; n' (0.25), n'' (0.08) with maximum desirability of 0.99. The viscoelastic strength increased with initial aging time (0-180 min) for undisturbed optimized hydrogel (1.6%, w/v at 30 ± 1 °C) confirmed by Jeffrey and Kelvin-Voigt model. The conjecture for obtaining optimized hydrogel by formation of networks like pattern was further evidenced by high resolution TEM analysis.

The interaction effects of Aloe vera/HM pectin mix ratio (0.25-1.0), sucrose (0-60% w/w) and pH (3-7) on Power law model fitted responses were studied by ANOVA and response surface plots. Aloe vera concentration was found to be more influencing parameter for mix gel formation followed by sucrose content and pH. The numerical optimization technique suggested that reduction of sucrose from 60 to 40% w/w could be possible by addition of Aloe vera/HM pectin with a mix ratio (*r*) varying from 0.40 to 0.59 to obtain similar gel strength and having higher desirability. The predicted results further validated with experimental data at optimized conditions where, the average absolute relative deviation was 8.5%.

Key words: Reconstituted Aloe vera gel, rheological properties, morphological observations, FTIR, optimization, mix gel.