

Wettability of Chitosan Coating Solution on 'Fuji' Apple Skin

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ABSTRACT: Wettability of chitosan coating solutions on 'Fuji' apple skin in different surfactant concentration (Tween 80: 0, 10, 100, 1000 ppm) was investigated using the Du Nouy ring method and the sessile-drop method. The surface property of 'Fuji' apple skin as a coated solid surface was characterized by the Zisman plot. The critical surface tension of 'Fuji' apple skin was 18.7 dyne/cm. The surface tension of the chitosan coating solution was too high (61.5 dyne/cm) to wet the apple skin. Tween 80 as surfactant in water-borne coatings reduced the surface tension of the coating solution and enhanced its wettability. Surface morphology of the coated film was observed by scanning electron microscope. Surfactant driven autophilicity improved the adhesive force between coating solution and associative apple skin, and decreased the contact angle of coating solution.

Keywords: edible coatings, wettability, chitosan, surfactant, autophilicity

Introduction

SEVERAL TYPES OF EDIBLE COATING SOLUTIONS, SEMI-PERMEABLE BARRIERS to gas exchange (CO_2 , and O_2), have been applied for the preservation of fresh produce. Polyethylene-candelilla-wax coatings have been used for 'Valencia' oranges to extend shelf life and minimize quality changes (Hagenmaier 2000). Carnauba-based wax on pear was studied to decrease the susceptibility to friction discoloration (Amarante and others 2001).

The effectiveness of edible coatings for fruits and vegetables depends primarily on controlling the wettability of the coating solutions, which affects the coating thickness of the film (Park 1999). Edible-coating formulations must wet and spread on the fruit's surface uniformly and upon drying form a coating that has adequate adhesion, cohesion, and durability to function properly (Krochta and Mulder-Johnston 1997). Hershko and Nussinovitch (1998) indicated that suitable hydrocolloid coatings could only be achieved by further exploring the wettability of the coating solution. Coatings on fruits and vegetables that exceed a critical thickness can cause detrimental effects of reduced internal O_2 concentration and increasing CO_2 concentration from anaerobic fermentation. Tomatoes coated with 66.04 μm zein film produced alcohol and off-flavors internally (Park and others 1994).

In previous studies, little effort was made to study the wetting properties of the coating solution on a fruit's skin. The effective spreading of a coating solution on a fruit's skin is greatly influenced by the wettability of coating solutions. Hagenmaier and Baker (1993) coated grapefruits and oranges with various fruit waxes and examined the influence of surface tension of wax coatings on coating performance. Hershko and others (1996) studied penetration of hydrocolloid and cross-linking agents into garlic skin, and reported that the coating process involves wetting of the produce by the coating gum solution, and possible penetration of the solution into the skin followed by a possible adhesion between these two phases.

This study was designed to investigate the wettability of a chitosan coating solution on apple skin. The aim of this work was to: (a) define the surface properties for coated object, (b) study the wetting properties of the coating solution, and (c) control the wettability

of the coating solutions by investigating the interaction between the solution and solid surface.

Materials and Methods

Theoretical background

Wettability involves the interaction between a liquid and a solid. When a droplet of a liquid is deposited on a solid surface, two possibilities can occur (Figure 1). In the first case the solid surface is well wetted by the liquid and the contact angle θ , defined as shown in Figure 1, is low. In the second case the solid is poorly wetted and the contact angle is high.

The wettability of a solid by a liquid is determined by the balance between adhesive forces (Work of adhesion: W_a) of the liquid on the solid and cohesive forces (Work of cohesion: W_c) of the liquid. Adhesive forces cause the liquid to spread over the solid surface while cohesive forces cause it to shrink.

$$W_a = \gamma_{LV} + \gamma_{SV} - \gamma_{SL} \quad W_c = 2 \gamma_{LV} \quad (1)$$

The contact angle of a liquid drop on a solid surface is defined by the mechanical equilibrium of the drop under the action of three interfacial tensions: solid-vapor (γ_{SV}), solid-liquid (γ_{SL}), and liquid-vapor (γ_{LV}). This equilibrium relation is known as Young's equation (Rulon and Rorbert 1993).

$$\cos \theta = (\gamma_{SV} - \gamma_{SL}) / \gamma_{LV} \quad (2)$$

When a solid is contacted by a liquid in the presence of vapor, the liquid will adhere well on the solid surface if the total free energy required for the creation of the new interface decreases. The physical significance of this energy change is the work needed to separate the solid and liquid from the solid/liquid interface. The equilibrium spreading coefficient (W_s) is defined by Equation 3 (Rulon and Rorbert 1993) and it can only be negative or zero.

$$W_s = W_a - W_c = \gamma_{SV} - \gamma_{LV} - \gamma_{SL} \quad (3)$$