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Effect of drying temperature and beeswax content on moisture isotherms of whey protein emulsion film

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Abstract

The objective of this investigation was to study the effect of drying temperature and beeswax (BW) content on moisture sorption behavior of whey proteins emulsion films. For this purpose, films were obtained by the casting method and dried at two selected temperatures (5 and 25 ºC) and constant relative humidity (RH) (58%). After drying, films were removed from the casting plates and were conditioned in the environmental chamber set at 25 °C and 58% RH for 3 days. Subsequently, portions of 400 mg of film were placed in glass bottles and pre-dried in desiccators containing drierite (a_w=0) during 10 days. Then, the bottles were placed in hermetically sealed glass jars containing 10 different desiccants to achieve a_w ranging from 0.11 to 0.90, and allowed to reach equilibrium. The analyses were made in quintuplicate at 25 ºC. The equilibrium moisture content (EMC) was determined by drying samples in an oven and the experimental data were fitted by the Brunauer-Emmett-Teller (BET) and the Guggenheim-Anderson-De Boer (GAB) models. The results showed that both models were effective to describe the moisture sorption behavior of the films. The GAB model gave better fit than the BET model. The increase of the drying temperature of 5 to 25 ºC and the incorporation of lipids reduced the EMC of whey protein emulsion films. Finally, data from experimental sorption isotherms are a useful tool to predict the effect of the environmental conditions that surround the film on its properties; particularly considering that the stability of an edible film is function of its mechanical and moisture barrier properties and both are strongly influenced by the presence of water, film formulation and drying and storage conditions.

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Keywords: Whey protein emulsion films; drying temperature; sorption behavior

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1. Introduction

Edible films and coatings have received great interest in recent years because they can extend the shelf life and improve the food quality by providing a barrier to mass transfer, carrying food ingredients and/or improving the mechanical integrity or handling characteristics of the food [1]. An edible film prevents texture decay particularly in fruits and vegetables, since water is essential for preservation of cell turgor [2].

Whey proteins have excellent nutritional and functional properties and the ability to form films; therefore they are a good constituent for the manufacture of edible coatings [3]. However, because of their hydrophilic nature, these coatings will absorb water from the surrounding media or from the food product. Several authors reported that physical and barrier properties of hydrophilic protein films can be significantly influenced by the moisture concentration in the film [4, 5]. Consequently, data from experimental sorption isotherms are a useful tool to predict the effect of the environmental conditions that surround the film on its properties; particularly considering that the stability of an edible film is function of its mechanical and moisture barrier properties and both are strongly influenced by the presence of water, which is related to film formulation and both drying and storage conditions. Accordingly, the objective of this investigation was to study the effect of drying temperature and beeswax (BW) content on moisture sorption behavior of whey proteins emulsion films.

2. Materials & Methods

2.1. Materials

Whey protein concentrate (WPC) 80% (Arla Food Ingredients S.A., Buenos Aires, Argentina), Beeswax (BW) (yellow, refined, Sigma-Aldrich), glycerol (Gly) (Cicarelli, Argentina), potassium sorbate (Anedra, Argentina) and Tween 80 (Anedra, Argentina).

2.2. Film formation

Aqueous solutions of 8% (w/w) WPC were plasticized with Gly and added with 0, 20 and 40% of BW [6]. Then, films were obtained by pipetting 8 g of the degassed solutions on 90 mm diameter disposable polyethylene Petri dishes. Films were dried on a leveled surface in an environmental chamber Tabai Comstar PR 4GM (Tabai Espec. Corp., Osaka, Japan) at two selected temperatures (5 and 25 °C) and constant relative humidity (RH) (58%). After drying, films were removed from the casting plates and were conditioned in the environmental chamber set at 25 °C and 58% RH for 3 days.

2.3. Moisture sorption isotherm

Film portions of 400 mg were placed in glass bottles previously weighted and were pre-dried in desiccators containing drierite (a_w=0) during 10 days. Then, the bottles were placed in hermetically sealed glass jars containing desiccants. Ten different humidity conditions were obtained using saturated salt solutions of LiCl, $KC_2H_3O_2$, $MgCl_2{\cdot}6H_2O$, K_2CO_3, $Mg(NO3)_2{\cdot}6H_2O$, NaBr, SrCl·6H$_2$O, NaCl, KCl and $BaCl_2{\cdot}2H_2O$ with an RH of 0.11, 0.22, 0.33, 0.43, 0.53, 0.58, 0.71, 0.75, 0.84, 0.90, respectively [7]. The film portions were allowed to reach equilibrium at 25 ºC in the relative humidity corresponding to each salt solution during 10 days. After that, glass bottles were weighted to obtain the sample weight at equilibrium and then they were dried at 105 ºC during 4 hours to obtain the weight of the dry sample. The analyses were made in quintuplicate. The equilibrium moisture content (EMC) was determined and the experimental data were fitted by the Brunauer-Emmett-Teller (BET) and the Guggenheim-Anderson-De Boer (GAB) models as followed: