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Stability and physicochemical properties of model salad dressings prepared with pregelatinized potato starch

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ABSTRACT

The effects of pregelatinized potato starch concentration (PSC) ranged from 0 to 5 wt% on the physical stability, color, rheological, textural, and sensory properties of model salad dressings prepared with 2 wt% dried egg yolk (DEY) or sodium caseinate (SC) were explored. All dressings showed shear-thinning behavior with yield stress. Raising PSC increased storage (G') and loss (G'') moduli decreasing loss tangent ($\tan\delta$) and samples containing $\geq$3 wt% starch showed a weak gel-like ($\tan\delta < 1$) response. A generalized Cox–Merz rule was applicable to indicate shear/strain sensitivity of the dressings structures. Rheological characterization based on Bohlin's parameters (A, z) was useful for distinguishing physical stability of dressings made with different formulations. Changes in color were generally very small and mainly PSC-dependent. Correlation analyses revealed that sensory descriptors could be satisfactory modeled with the appropriate instrumental data. Overall, the results proved that pregelatinized potato starch may be suitable ingredient in low-fat dressings applications.

1. Introduction

Commercial salad dressings are oil-in-water (o/w) emulsions frequently used by the food industry to enhance the attractiveness and tastiness of different products. These systems are thermodynamically unstable, and the instability is particularly accelerated, when the fat content is reduced below 60–65% (Drakos & Kiosseoglou, 2008; Ma, Boye, Fortin, Simpson, & Prasher, 2013). Physical stability of dressings can be extended for reasonable period of time, creating kinetic barriers to droplets coalescence by applying effective emulsifiers and thickeners/stabilizers (Bortnowska, Krzemińska, & Mojka, 2013; Dickinson, 2003).

Hen egg yolk (EY) is a key ingredient in a wide variety of food emulsions, as it combines excellent emulsifying properties and appreciated organoleptic characteristics (Laca, Sáenz, Paredes, & Díaz, 2010). Native EY consists of mixtures of lipids and proteins noncovalently bound in the form of large lipoprotein complexes, which confer on EY a high emulsifying capacity. However, EY in native form is not microbiologically stable, therefore spray-drying as the preservative process is commonly used to ensure longer stability of final product (Moros, Franco, & Gallegos, 2002). Sodium caseinate (SC) is a heterogeneous mixture of disordered amphiphilic proteins (α_{s1}-, α_{s2}-, β- and κ-) having ability for rapidly conferring a low interfacial tension during emulsification (Farshchi, Ettelaie, & Holmes, 2013; Huck-Iriart, Álvarez-Cerimedo, Candal, & Herrera, 2011). SC can easily create films from aqueous solutions because of its random coil nature and ability to form extensive intermolecular hydrogen, electrostatic and hydrophobic bonds, resulting in an increase of the interchain cohesion (Khwaldia, Banon, Perez, & Desobry, 2004). Starch is made up of two polymers of D-glucose: amylose, an essentially unbranched $\alpha[1\rightarrow4]$ linked glucan and amylopectin, which has chains of $\alpha[1\rightarrow4]$ linked glucoses arranged in a highly branched structure with $\alpha[1\rightarrow6]$ branching links (Copeland, Blazek, Salman, & Tang, 2009). This hydrocolloid is a major source of carbohydrates in the human diet and widely used in the food industry as a thickening and stabilizing agent (Dolz, Hernández, & Delegido, 2006). Over the last few decades, starch has been modified to improve its properties and tolerance to processing conditions. Physical modification (e.g. pregelatinization) of starch can be safely used because it does not involve any chemical presence (Kaur, Ariffin, Bhat, & Karim, 2012).

The interactions between components of food-grade emulsifiers and polysaccharides can be either detrimental or beneficial and

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this greatly affects properties of final product (Dickinson, 2003). Previously, we found that application of pregelatinized waxy maize starch allowed to develop cold prepared food emulsions with a very wide range of textural and rheological properties (Bortnowska, Balejko, Tokarczyk, Romanowska-Osuch, & Krzemińska, 2014). However, the effects of pregelatinized starches containing higher amylose/amylopectin ratios than waxy-type ones on the physicochemical characteristics of salad dressings have not been well evidenced.

The objective of the present work was to examine the influence of pregelatinized potato starch concentration on the stability, physicochemical and sensory properties of low-fat salad dressings prepared with dried egg yolk and sodium caseinate.

2. Materials and methods

2.1. Materials and reagents

Spray-dried sodium caseinate (91.2 wt% protein, 1.8 wt% lipids, 4.8 wt% moisture) and dried egg yolk (33.1 wt% protein, 56.7 wt% total lipids having 28.4 wt% phospholipids, and 3.9 wt% moisture) were purchased from Duncean (Kamień Pomorski, Poland). Pregelatinized potato starch, Novation® 6600 (20 wt% amylose) was donated by Ingredion (Hamburg, Germany). Rapeseed oil (7 wt% saturated, 65 wt% monounsaturated and 28 wt% polyunsaturated fatty acids) was bought from a local retailer. Analytical grade: potassium sorbate, hydrochloric acid (HCl), and sodium hydroxide (NaOH) were obtained from Hartim (Szczecin, Poland). Double-distilled water was used to prepare all solutions, and dressings. Composition of the ingredients is reported as stated by the producers.

2.2. Model salad dressings preparation

Aqueous phases were prepared by dispersing dried egg yolk (DEY), sodium caseinate (SC) and potato starch (PS) in double-distilled water with addition of potassium sorbate, followed by stirring at room temperature overnight to ensure complete dispersion and hydratation. The oil-in-water emulsions were manufactured by homogenizing (1 min, 14 000 rpm) the aqueous mixtures of DEY and SC with rapeseed oil, using a laboratory-scale MPW 302 homogenizer (Mechanika Precyzyjna, Warszawa, Poland). The model salad dressings were produced by mixing (speed 8, 2 min) emulsion samples with the aqueous solutions of PS using a K4555 kitchen robot (KitchenAid, St. Joseph, MI, USA). The pH of the dressings was adjusted to 7.0 with 0.1 M HCl or 0.1 M NaOH. Finally the dressings contained 20 wt% rapeseed oil, 2 wt% DEY or SC, 0.1 wt% potassium sorbate and PS ranged from 0 to 5 wt%. The control samples were prepared at the same procedures without adding PS. All experiments were carried out at a fixed temperature of 22 ± 0.5 °C.

2.3. Stability test

Stability of salad dressings to creaming (ESC) and fat holding capacity (FHC) was determined after accelerated ageing. Aliquots (~8.0 mL) of the dressings were transferred to the 10 mL test tubes which were tightly sealed with plastic caps and then centrifuged at $2400 \times g$ for 15 min, using a MPW 350 centrifuge (Med.-Instruments, Warszawa, Poland). The ESC parameter was derived from the relation: $\text{ESC}\ (\%) = (H_C/H_T) \times 100$, where: H_C, the height of the creamed layer and H_T, the total height of emulsion, whereas, the FHC one was calculated as follows: $\text{FHC}\ (\%) = (V_R/V_A) \times 100$, where: V_R, oil volume remained in the dressing system after centrifugation and V_A, oil volume added to the sample during its formation.

2.4. Color assessment

Color of the salad dressings was measured with a HunterLab Model D25-2A Digital Color Difference Meter (Hunter Associates Laboratory Inc., Fairfax, VA, USA) at 2° view angle. The calibration was done with a white C2-6544 plate ($X = 86.30$, $Y = 88.51$, $Z = 101.99$). Color coordinates were expressed as lightness (L^*), redness/greenness ($+/-a^*$) and yellowness/blueness ($+/-b^*$). Experimental data were characterized in terms of colour distance: $\Delta E_{a^*b^*} = [L^{*2} + a^{*2} + b^{*2}]^{1/2}$, whiteness index: $\text{WI} = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2}$, hue angle: $H^\circ = tg^{-1}(b^*/a^*)$ and total color difference: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ where: ΔL^*, Δa^* and Δb^* are differences between the adequate color parameters of the containing PS and control samples.

2.5. Texture profile analysis

The texture profile analysis (TPA) was performed according to Bortnowska et al. (2014) using a back-extrusion (pseudo-compression) test on a Texture Analyzer model TA-XT2 (Stable Micro Systems Ltd., Surrey, UK) equipped with back extrusion cell (A/BE), 5 kg load cell, and 45 mm compression plate diameter. The force-time forces were analyzed using Texture Expert® for Windows® v. 1.11 equipment software and the determined parameters were firmness (N), consistency (N s), cohesiveness (N) and adhesiveness (N s).

2.6. Determination of rheological properties

Rheological properties of salad dressings were conducted using a strain/stress controlled AR 2000ex rheometer (TA Instruments, New Castle, DE, USA) equipped with a cone-plate configuration (1° cone angle, 40 mm diameter, 26 μm gap) and a Peltier temperature controlling system. All dressing samples were allowed to rest for 5 min after loading to allow temperature equilibration and induced stress to relax. Steady-state flow measurements were carried out in the range of $1\text{–}600\,\text{s}^{-1}$ and the rheological parameters were obtained from the TA Rheology Advantage Data Analysis equipment software V 5.4.7. Experimental flow curves were fitted to the Herschel–Bulkley (H–B) model: $\sigma = \sigma_0 + K \cdot \dot{\gamma}^n$, where: σ, shear stress (Pa); σ_0, yield stress (Pa); K, consistency coefficient (Pa s^n); $\dot{\gamma}$, shear rate (s^{-1}) and n, flow behavior index (–). The effective viscosity: $\eta_{\text{eff}}(\text{Pa s}) = \sigma_0/\dot{\gamma} + K\dot{\gamma}^{n-1}$ for the H–B model was calculated at $\dot{\gamma} = 100\,\text{s}^{-1}$. Dynamic oscillatory test was performed over an angular frequency (ω) range of 1–50 rad/s within linear viscoelastic region at constant shear stress of 0.6 Pa. Storage (elastic) modulus (G', Pa), loss (viscous) modulus (G'', Pa), complex modulus: $G^*\ (\text{Pa}) = (G'^2 + G''^2)^{1/2}$, loss tangent: $\tan\delta = G''/G'$, and complex viscosity: $\eta^*\ (\text{Pa s}) = G^*/\omega$, were thus obtained as a function of ω. The plateau modulus: $G_N^0\ (\text{Pa}) = [G']_{\tan\delta\rightarrow\text{minimum}}$ was determined as described by Ma et al. (2013). The G', G'' and η^* parameters were modeled as power functions using following expressions: $G' = K'\ \omega^{n'}$, were thus obtained as a function of $G'' = K''\omega^{n''}$, and $\eta^* = K^*\omega^{n^*-1}$, where: K', K'', K^* ($\text{Pa s}^{n'}$, $\text{Pa s}^{n''}$, Pa s^{n^*}) and n', n'', n^* (–), are consistency coefficients and behavior indexes, respectively. Relationship between the steady-state shear and oscillatory data was established using a generalized Cox–Merz rule: $\eta^*(\omega) = k\{[\eta_a(\dot{\gamma})]^\beta\}_{\omega=\dot{\gamma}}$, where: η_a, apparent viscosity (Pa s) and k, β, constants. The Bohlin's parameters were assessed from the equation: $G^* = A\omega^{1/z}$, where: z, coordination number (dimensionless) and A, proportional coefficient ($\text{Pa s}^{1/z}$) (Manoi & Rizvi, 2009).