Journal of Food Engineering 142 (2014) 221–227

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

Effect of formulation and storage on physicochemical and flow properties of custard flavored with caramel jam

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ARTICLE INFO

Article history:
Received 18 December 2013
Received in revised form 22 May 2014
Accepted 8 June 2014
Available online 17 June 2014

Keywords:
Flavored custard
Flow properties
Physicochemical properties
Caramel jam

ABSTRACT

The effects of formulation and storage time on the physicochemical and flow properties of dairy custards with caramel jam as a new flavor were studied. Systems were formulated following a factorial design including three concentrations of starch, three of caramel and three of protein. Both, the formula and storage time, influenced at different degree the analyzed physicochemical properties and flow behavior. Moisture was stable, while a decreasing in pH and brightness, an increasing in acidity, redness and yellowness, were observed. The non-Newtonian response was adjusted to the Herschel–Bulkley and Bingham plastic equations at the upward and downward flow curves, respectively. The custards consistency increased with the addition of formula components and decreased with storage, while the shear thinning nature of the fresh systems declined with storage as a result of changes in gel structure. Quantification of the thixotropic area completed the rheological analysis of the custards as non-Newtonian time dependent food materials.

1. Introduction

The starch-based custards are widely consumed around the world (Tárrega and Costell, 2006). Custards are desserts that have gained popularity due to their consistency, semisolid structure and different flavor presentations, with flavors like chocolate and vanilla, among others. Basically, these products are formulated with milk, sucrose, thickeners (starch and hydrocolloids), flavors and colorants. Corn starch is generally included in the formulation by the food industry, because it provides structure and texture to the product.

Starch is a polysaccharide widely used for its gelling ability in dairy products (Langendorff et al., 2000; Yanes et al., 2002). This capability is developed during heating, in which the starch molecules vibrate breaking the intermolecular hydrogen bridges of the amorphous zones of the granules, causing them to swell by progressive and irreversible absorption of water which is finally ligated to the structure (Pineda-Gómez et al., 2010), improving the food texture. In addition, proteins are currently used to enrich foods and to produce a variety of food presentations with characteristic consistencies, such snacks, smoothies, soups and creams (Tárrega et al., 2012).

The nutritional and sensory characteristics provided by protein, promote its consumption by various groups of consumers with special dietary requirements, as athletes (Hoffman and Falvo, 2004), elderly (Chernoff, 2004), vegetarians (Campbell et al., 1999) or cancer patients (Counous, 2000). Whey proteins are globular proteins including β-lactoglobulin, α-lactalbumin, albumin, immunoglobulin, and several minor proteins and enzymes (Bordin et al., 2001), that are and can be used in the manufacture of many food products as modifiers of texture due to their ability to form gel structures (Kinsella and Whitehead, 1989) and to facilitate moisture retention during processing (Hayes et al., 2005). Studies in enriched starch custards with animal (Nordli et al., 2009), or vegetal protein contents (Okoye et al., 2008), or mixtures of both (Tárrega et al., 2012) have being carried out to determine the influence of these ingredients on the physicochemical and rheological properties, besides to the nutritional contribution. Most of the studies on custards have been focused on sensorial evaluations (Camejo et al., 2010; Tomaschunas et al., 2013; Mosca et al., 2014).

On the other hand, caramel jam or cajeta is a typical dairy product of the Mexican culture prepared with goat milk and glucose, in which an evaporation process is carried out. This dairy food, containing proteins and sugars, is produced by using high temperatures that yields a distinctive brown color resulting from non-enzymatic browning. It is consumed alone as a dessert, or as a jelly sweetener in ice cream, pie filling, prepared foods (Rocha et al.,

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http://dx.doi.org/10.1016/j.jfoodeng.2014.06.013
0260-8774/

Nomenclature

A_r	relative hysteresis area was (%)
A_t	thixotropic area (Pa s^{-1})
C	constant in the Casson model
CJ	caramel jam (%, or g/100 g)
K	consistency coefficient (Pa s^n)
N	flow behavior index ((dimensionless), g)
ST	corn starch (%, or g/100 g)
WP	whey protein (%, or g/100 g)
γ	shear rates (s^{-1})
τ	shear stress values (Pa)
τ_0	yield stress (Pa)
η_p	plastic viscosity (Pa s)

2006), and other dairy liquid foods (Ramírez-Sucre and Vélez-Ruiz, 2011, 2013).

In general, the custards show a time dependent flow behavior with shear thinning, typical of weak gels. Recently, significant differences in the rheological behavior of commercial samples (Batista et al., 2002; Tárrega et al., 2004) and model systems with different formulations (Lethuaut et al., 2003; Abu-Jdayil et al., 2004; Vélez-Ruiz et al., 2005, 2006; Elizondo Rosales et al., 2008; Tárrega et al., 2012; Toker et al., 2013), have been investigated.

However, there is not available information about the influence of caramel jam addition combined with whey protein on the properties of starch-based custards. Therefore, the objective of this work was to study the effect of the addition of caramel jam and whey protein, as novel ingredients, on the physicochemical and flow properties of custard dairy systems, in which their stability through three weeks of storage was also analyzed.

2. Materials and methods

2.1. Materials

In this study, whey protein isolate (Prowinner, PRONAT, Linio, Mexico), corn starch (Maizena, Unilever, Mexico), caramel jam (Real Potosí, SLP, Mexico), selected without preservatives and with a declared composition of 66.7 carbohydrates; 7.5 fat; 7.5 protein; 0.13 minerals and the rest of water (g/100 g), and commercial sucrose were used to prepare the samples. Skim milk corresponded to a commercial brand (Svelty, Nestlé, Mexico).

2.2. Custard preparation

For the physicochemical and rheological determinations, samples of 200 g were prepared, varying the levels of corn starch (ST) at 3.0, 4.0 and 5.0 g/100 g; whey protein (WP) at 4.0, 5.0 and 6.0 g/100 g; and caramel jam (CJ) 8.0, 9.0 and 10.0 g/100 g in skim milk (Table 1). For each sample, the ingredients were weighed into a glass and mixed in deionized water, mixing the corresponding quantities of all the ingredients under mechanical stirring for 10 min and lately, warmed up to reach 90 ± 1 °C. Subsequently, the glass container was placed in a water bath at 25 ± 1 °C–10 min, and allowed to stand until reaching room temperature. Then the systems were transferred to 100 mL flasks for storage in refrigeration at 4 ± 1 °C for further analysis. Two batches were prepared for each composition for its subsequent analysis. The levels of starch and protein were based on a custard Mexican recipe, whereas the levels of cajeta were based on a previous sensorial test (data not shown) to detect consumer preferences.

2.3. Physicochemical analysis

For measurement of pH at room temperature a digital potentiometer (Beckman, Denver, CO, USA), was used, it was previously calibrated. The moisture content was determined by water evaporation (AOAC, 1984). The acidity was measured by titration of 10 mL of sample, by using phenolphthalein, as well as NaOH (0.1 N) (Soukolis et al., 2007). The color of the custard was quantified in a color meter (Color Gard System/05, Hunter Labs, Reston, VA, USA) previously calibrated with white and black plates, with normalized reflectance values of the parameters L, a and b (92.89, −1.05 and 0.82, respectively). Two replicates were performed on each sample.

Syneresis (g/100 mL) was determined by weight difference of the supernatant from the initial custard samples (10 mL) and after centrifugation at 1200 g during 10 min (Guinee et al., 1995); two replicates were performed for this test.

2.4. Flow measurements

All flow determinations were performed with a Brookfield concentric cylinders digital viscometer (LVDE115, Brookfield Engineering Laboratories, Inc., Boston, MA, USA). Viscometer was adjusted to zero and the spindle LV4 was set in the instrument, generating a gap of 2.09 cm (radius of the glass container 2.25 cm, radius of the LV4 spindle 0.16 cm). The flow behavior was determined by recording the shear stress values to deform the samples with the correspondent shear rates, linearly increased from 1 to 120 s^{-1} for 60 s (upward flow curve). The same methodology was carried out in decreasing order during the same time (downward flow curve). Data of upward curves were adjusted to Herschel and Bulkley equation $\tau = \tau_0 + K\gamma^n$), while the downward curves were adjusted to Bingham plastic equation ($\tau = \tau_0 + \eta_p\gamma$). The yield stress, flow behavior index, consistency coefficient and plastic viscosity characterized the flow behavior of the custard systems. The yield stress was calculated from Casson model ($\tau^{0.5} = \tau_0^{0.5} + C\gamma^{0.5}$), while the parameters n and K (or η_p) were obtained by a linear correlation of log ($\tau - \tau_0$) versus log γ To check the accuracy of these parameters, a computer package was also utilized (KaleidaGraph 4.1, Synergy Software, Reading, PA, USA), giving the same values.

The thixotropic area was calculated to express the time dependence of the flow response of the different systems. The calculation of the thixotropic area (A_t) was performed by programming the difference of integrals of the upward and the downward curves equations by using the KaleidaGraph software (v 4.1, Synergy Software, Reading, PA, USA), by applying the next relationships.

$$A_t = \sum_{i=1}^{n} (A_{\text{upward curve}} - A_{\text{downward curve}})$$

$$A_t - \sum_{i=1}^{n} \left(\int_{\gamma=0.1}^{\gamma=120} (\tau_0 + K\gamma^n) d\gamma - \int_{\gamma=0.1}^{\gamma=120} (\tau_0 + \eta_p\gamma) d\gamma \right)$$

Subsequently the relative hysteresis area was obtained as $A_r = (-A_t * 100)/A_{\text{upward}}$ (Tárrega et al., 2004). Measurements were carried out in duplicate at room temperature (25 ± 2 °C) at 0, 7, 14 and 21 days.