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Syneresis and rheological behaviors of set yogurt containing green tea and green coffee powders

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ABSTRACT

This study aimed to investigate the effect of added green coffee powder (GCP) and green tea powder (GTP) on syneresis behavior and consistency of set yogurts. Adding GCP (1 or 2%) decreased syneresis rate. It was confirmed that the effect of GTP on the syneresis rate was concentration dependent. In comparison to the control, GTP decreased syneresis rate when it was added at 0.02%, but it caused an increase when added at 2%. No significant difference was observed in the syneresis rates when GTP was added at amounts of 1 and 0.01%, until 14 and 7 d of storage, respectively. The Herschel-Bulkley model parameters indicated that the consistency of control was considerably lower than GCP yogurts during 14 d, whereas it was found to be higher at the end of storage. The GTP yogurt results showed that the consistency coefficients of GTP yogurts were different from the control samples until 14 d of storage. In conclusion, GTP and GCP behaved differently in acidified gel networks of set yogurt, modifying its rheological behavior, as they have different profiles and concentrations of polyphenols.
Key words: set yogurt, green tea, green coffee, protein-polyphenol interaction, syneresis rate

INTRODUCTION

Yogurt is a widely consumed dairy product because of its positive health effects (Loveday et al., 2013). Casein plays the most important role in the formation of gel matrix via aggregation of casein micelles as the pH approaches 4.6 as a result of lactic acid production during fermentation (McCann et al., 2011; Cui et al., 2014). Set yogurts, usually fermented "in pack," have firmer structure than stirred yogurts because there is no mechanical effect like shearing (Loveday et al., 2013).

Rheology builds a bridge between structural microscopic aspects and continuous macroscopic parameters (Gabriele et al., 2001). The microstructure and the rheological properties of set yogurts are considerably critical to product quality and shelf life (Nguyen et al., 2015). Syneresis, serum release from the gel matrix, is regarded as a technological defect of set yogurts. The addition of milk-based compounds, use of some polysaccharides and protein hydrocolloids, changing the concentration of starter culture, use of stabilizers such as xanthan gum and pectin, and changing the process conditions have been reported to enhance the technological properties of yogurt (Jaros et al., 2002; Amatayakul et al., 2006; Riener et al., 2010; Delikanli and Ozcan, 2014; Puvanenthiran et al., 2014; Nguyen et al., 2015).

Polyphenols, secondary plant metabolites, have the ability to interact with proteins, resulting in the formation of protein-polyphenol complex (Woof and Pierce, 1968; von Staszewski et al., 2011; Jakobek, 2015). Interactions between polyphenols and proteins are mostly based on multiple weak interactions, mainly hydrophobic, van der Waals, hydrogen bridge-binding, and ionic interactions formed between AA side chains and polyphenol aromatic rings, indicating that the association of polyphenols with proteins is principally a surface phenomenon. Hasni et al. (2011) examined that the interactions between tea polyphenols and α-CN and β-CN using Fourier transform infrared, UV-visible fluorescence spectroscopic methods and found that the binding mechanisms were both hydrophobic and hydrophilic interactions. The formation or precipitation of protein-polyphenol complex was modeled by many researchers (Siebert et al., 1996; Charlton et al., 2002; Jobstl et al., 2004; Lin et al., 2004; Poncet-Legrand et al., 2006; Richard et al., 2006).

Even when compared with other polyphenol-rich, plant-based foods, green tea and green coffee contain high levels of polyphenols. Chlorogenic acid represents 4.1 to 11.3 g/100 g of the green coffee seeds, whereas catechins constitute 30 to 42% of green tea extract solids (Graham, 1992; Farah, 2012). This study aimed to investigate the effect of protein-polyphenol interaction on the syneresis of set type yogurts by using green coffee and green tea powders. The effects of different amounts

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of green tea or green coffee powders were determined on syneresis rate and consistency of set yogurts using a centrifugal acceleration test and rheological measurement, respectively, during 3 wk of storage at 4°C.

MATERIALS AND METHODS

Chemicals and Consumables

Pasteurized (85°C and 5 min) and homogenized milk (3% protein, 3% fat), green coffee beans (*Coffea canephora* var. *robusta*), and green tea leaves were supplied from a local market in Turkey. A freeze-dried lactic acid culture YF-L812, containing a mixture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, was obtained from CHR Hansen (Victoria, Australia).

Sodium carbonate, sodium hydroxide, potassium sulfate, boric acid, hydrochloric acid (37%), and sulfuric acid (95%) were purchased from Merck (Darmstadt, Germany). Ethanol (96%) and Folin-Ciocalteu Reagent (2 *N*) were obtained from Sigma-Aldrich (Steinheim, Germany). Cupric sulfate pentahydrate was purchased from Fluka Chemie AG (Buchs, Switzerland). Gallic acid (98%) was from Acros (Geel, Belgium).

Preparation of Green Tea and Green Coffee Powders

Green tea brew was prepared by the extraction of coarsely ground green tea leaves. Thirty grams of green tea was extracted into 1 L of boiling water by keeping it at 90°C in a water bath for 30 min. Green tea leaves were removed by using a filter paper (Macherey-Nagel 751/60). Then, the green tea extract was immediately lyophilized to obtain green tea powder (**GTP**). The freeze-drying was performed for 48 h (Christ Alpha 1–2 LD+, Osterode, Germany) operated at 0.1 Pa and ice condenser temperature of 76°C.

Six grams of finely ground green coffee was weighted into an espresso cap and the first 25 mL of extract was collected from the espresso machine (Ecov 311. BK Icona Vintage, DeLonghi, Treviso, Italy). The same procedure was repeated until enough extract was obtained. The combined green coffee extract was lyophilized to obtain green coffee powder (**GCP**). Both GCP and GTP were stored at −18°C until the yogurts would be prepared.

The total phenolic content of the GTP and GCP was determined according to the Folin-Ciocalteu colorimetric method (Yilmaz and Gokmen, 2013). One hundred milligrams of powders was mixed with 10 mL of ethanol-water (50:50, vol/vol) in a test tube. Then, the samples were vortexed for 1 min and centrifuged at 5,500 × *g* for 3 min at room temperature. Then, 0.2 mL of the supernatant was transferred to another test tube and mixed with 0.8 mL of 0.2 *N* Folin-Ciocalteu reagent and 0.8 mL of 20% aqueous Na_2CO_3, consecutively. The reaction mixture was subsequently incubated at 25°C for 2 h. Then, the absorbance of the samples was measured at 765 nm using a Shimadzu model 2100 variable wavelength UV-Vis spectrophotometer (Shimadzu, Kyoto, Japan). Standard calibration curve was prepared by using gallic acid between the ranges of 0 to 100 mg/L. Three independent measurements were performed and the total phenolic content was expressed as milligrams of gallic acid equivalents (**GAE**) per gram of sample.

Preparation of Yogurts

Pasteurized milk was heated to 42°C and then rapidly inoculated with direct vat set starter culture (3 g/100 mL). As soon as the inoculation was performed, GCP (0, 1, and 2%) or GTP (0, 0.01, 0.02, 1, and 2%) was immediately added to the milk. The samples were incubated at 42°C until the pH reached to 4.6 in 3 h and then at 4°C for 18 h. The GCP-added yogurt (**GCP yogurt**) and GTP-added yogurt (**GTP yogurt**) samples were stored at 4°C for 21 d and the analyses were performed on d 1, 7, 14, and 21 of storage. All yogurts were prepared in duplicate with one lot of milk.

The pH values (PHM210 MeterLab, Lyon France) and the color information in CIE L*a*b* space (Minolta colorimeter CM3600d, Tokyo, Japan) were monitored to evaluate quality characteristics of yogurts during cold storage. The pH and color measurement were performed at room temperature. The color values of the control sample were taken as the reference to calculate color differences (**ΔE**) of GCP and GTP yogurts, by using Equation [1]. In CIE L*a*b* space, L* represents luminance or lightness. The a* and b* chromatic components represent colors from green to red, and blue to yellow, respectively.

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2}. \quad [1]$$

Determination of the Syneresis Rate

The syneresis rates of yogurts were determined by a centrifugal acceleration test. Five grams of yogurt sample was placed in a test tube and centrifuged at 1,200 × *g* for 0, 3, 6, 9, 12, and 15 min at room temperature. At each time interval, the volume of the serum separated from the samples was measured to estimate the initial rate of syneresis, which was expressed as milliliters of serum released per gram of sample per unit of time. The average of the 5 times (except 0) tested was reported to evaluate the syneresis rate for that day.