J. Dairy Sci. 99:1–11
http://dx.doi.org/10.3168/jds.2016-10974

Composition and functionality of whey protein phospholipid concentrate and delactosed permeate

M. A. Levin,* K. J. Burrington,† and R. W. Hartel*[1]
*Department of Food Science, and
†Center for Dairy Research, University of Wisconsin-Madison, 1605 Linden Drive, Madison 53706-1565

ABSTRACT

Whey protein phospholipid concentrate (WPPC) and delactosed permeate (DLP) are 2 coproducts of cheese whey processing that are currently underused. Past research has shown that WPPC and DLP can be used together as a functional dairy ingredient in foods such as ice cream, soup, and caramel. However, the scope of the research has been limited to 1 WPPC supplier. The objective of this research was to fully characterize a range of WPPC. Four WPPC samples and 1 DLP sample were analyzed for chemical composition and functionality. This analysis showed that WPPC composition was highly variable between suppliers and lots. In addition, the functionality of the WPPC varies depending on the supplier and testing pH, and cannot be correlated with fat or protein content because of differences in processing. The addition of DLP to WPPC affects functionality. In general, WPPC has a high water-holding capacity, is relatively heat stable, has low foamability, and does not aid in emulsion stability. The gel strength and texture are highly dependent on the amount of protein. To be able to use these 2 dairy products, the composition and functionality must be fully understood.

Key words: whey protein phospholipid concentrate, delactosed permeate, whey functionality, whey composition

INTRODUCTION

Whey protein phospholipid concentrate (**WPPC**) and delactosed permeate (**DLP**) are products from the processing of cheese whey and are currently a disposal concern for the dairy industry. Whey protein phospholipid concentrate is a coproduct of whey protein isolate produced from the microfiltration of whey protein concentrate (**WPC**), a process that separates the majority of the undenatured whey proteins from the fat, phospholipids, lactose, and denatured whey proteins. In 2015, the American Dairy Product Institute (2015) instituted a standard for WPPC composition: a minimum of 50% protein (dry basis), a minimum of 12% fat, a maximum of 8% ash, and a maximum of 6% moisture.

Whey protein phospholipid concentrate represents 14 to 18% of the total whey processed—approximately 32 million tonnes/year (Burrington, 2012). Delactosed permeate is produced in even greater quantities: 0.5 kg for every 1 kg of milk used in cheese production (Liang et al., 2009); DLP is an effluent of lactose crystallization from permeate and is high in lactose, organic acids, and minerals. Currently, only one ingredient manufacturer has commercialized a dry DLP and there exists no standard of identity. Both DLP and WPPC are currently underused in the food industry; they are primarily used for animal feed and spread on fields. If they could be used in value-added food applications, they would greatly benefit the dairy industry in terms of increased profitability and decreased disposal costs.

The composition, variability, and drying capabilities of DLP have been studied (Bund and Hartel, 2009; Liang et al., 2009). The addition of WPPC aids in the drying of DLP because of an increase in protein levels between 20 and 30% (Bund and Hartel, 2009). Together, WPPC and DLP have been studied in food applications to replace emulsifiers, salt, eggs, and other dairy products in ice cream, soups, and confections (Burrington, 2011). However, the study of WPPC alone has been limited. Previous research has investigated how to prevent the fat in WPPC from oxidizing (Jensen at al., 2011) or how to incorporate WPPC into ice cream (Bund and Hartel, 2013; Daw and Hartel, 2015), but only one supplier of WPPC was used. The functionality and variability of WPPC has not yet been investigated.

Whey protein phospholipid concentrate is composed primarily of whey proteins and dairy lipids from the milk fat globule membrane. These 2 components have previously been shown to have functional properties. The phospholipids from the milk fat globule membrane

Received February 1, 2016.
Accepted May 31, 2016.
[1]Corresponding author: rwhartel@wisc.edu

have good emulsifying characteristics because of their polar and nonpolar composition. Whey proteins have strong gelling properties and high water-holding capacity, they are heat stable, and they form strong foams (Walstra et al., 2006). However, their functionality is highly dependent on the other components of the whey powders. For example, WPC with high protein content and high fat content will not foam because the fat disrupts the viscoelastic protein layer between the air and liquid.

The characteristics and composition of WPPC depend on both the starting whey and the process for whey protein separation. In this study, we investigated the variability of WPPC across several suppliers for both compositional and functionality differences. Additionally, we added dried DLP to the WPPC to examine its effect on functionality and to see if these 2 low-value dairy products could be combined.

MATERIALS AND METHODS

Materials

Several WPPC powders were obtained: Isocill 6000 from Agropur Ingredients (Lacrosse, WI), Perham P_c-Protein from Bongards Creameries (Minneapolis, MN), Whey Phospholipid Protein Concentrate from Milk Specialties Global (Eden Prairie, MN), and Whey Protein Concentrate High Fat from Leprino Foods (Denver, CO). We obtained 2 batches from each supplier for this study, 6 mo apart. We obtained the only commercially dried DLP, Dairy Products Solid, from Leprino Foods.

Compositional Analysis

The total protein, fat, moisture, ash, lactose, and pH of the WPPC and DLP powders were determined according to standard AOAC methods (AOAC International, 2003) by the Center for Dairy Research (Madison, WI). The fatty acid composition and phospholipid composition of the WPPC powders were determined using standard GC methods (AOAC International, 2003) by POS-Bio Sciences (Saskatoon, SK, Canada).

Microscopy

All microscope images of WPPC samples were viewed using a Nikon Labphot-2 light microscope (Melville, NY) at 40× magnification. Images were recorded using a Qimagin QIcam camera (Surrey, BC, Canada) and analyzed using Image-Pro Plus software (Bethesda, MD). Two slides were prepared per sample, and 5 random images were taken per slide. To stain the protein, WPPC samples were hydrated in deionized water at 10% (wt/vol) for 1 h at room temperature. The WPPC solutions were stained with 0.1% (wt/vol) eosin Y (Fisher Scientific, Waltham, MA) at 10% (vol/vol) concentration. Eosin Y is a dye that binds basic amino groups to result in a bright pink color (Lewis, 2007). To stain the phospholipids, the WPPC was mixed with 0.1% (vol/vol) luxol fast blue MBS solution (VWR International, Radnor, PA) at a 10% (wt/vol) concentration and hydrated for 24 h at 65°C. Luxol fast blue is a diarylguanidine salt of sulfonated copper phthalocyanine; through an acid-base reaction, it forms a blue complex with phospholipids (Salthouse, 1962).

SDS-PAGE

Sodium dodecyl sulfate-PAGE analysis was used to investigate the type of proteins and denatured proteins found in the WPPC. The WPPC samples were diluted to 1 mg/mL in solution with and without β-mercaptoethanol (Sigma-Aldrich, Saint Louis, MO). Pre-cast 4 to 20% Mini-Protean TGX gels with 1× Tris-Gly-SDS buffer (Sigma-Aldrich) were used for analysis; 25 μL of sample was loaded into each lane and 5 μL of SDS-PAGE broad-range protein standard (BioRad, Hercules, CA) was used as a molecular weight standard. Gels were run at 200 V for 30 min and stained with Coomassie blue (BioRad) (Shapiro et al., 1967).

Functionality

All samples of WPPC and blends with DLP were stored in an airtight, antihumidity chamber at 21°C to prevent moisture absorption. All functionality tests were performed at both native pH and pH 7. All samples tested with pH 7 were hydrated with 0.1 *M* phosphate buffer (pH 7) and adjusted to the proper pH using 1 *N* HCl or 1 *N* NaOH. Only the second batch of WPPC samples was tested for functionality. The WPPC was blended with DLP at 3 ratios for the functionality tests: 0:100, 30:70, and 50:50 DLP:WPPC. All tests were performed in triplicate.

Water-Holding Capacity. Water-holding capacity (**WHC**) was determined at room temperature. The DLP:WPPC blends were hydrated at 10% (wt/vol), mixed using Fisher Gene II Vortex in a preweighed 15 mL centrifuge tube and allowed to incubate at room temperature for 1 h. The samples were centrifuged at 2,000 × *g* for 30 min in a Marathon 21 k/R centrifuge (Fisher Scientific). The supernatant was decanted into glass flasks and placed in a 100°C oven for 24 h to remove all water. The pellet and dry solids from the supernatant were weighed. Residual buffer or water in