J. Dairy Sci. 95:6252–6259
http://dx.doi.org/10.3168/jds.2012-5376

Effect of xylitol on the functional properties of low-fat process cheese

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ABSTRACT

Process cheese (PC) is a dairy food prepared by blending natural cheese, salt, emulsifying salts, and other dairy and nondairy ingredients, and heating with continuous agitation to produce a homogeneous product. Fat is a critical component of PC and plays an important role in its functional characteristics. The health concerns associated with fat consumption have led to an increase in the demand for low-fat dairy products. Reducing the fat content of PC results in poor functional properties such as increased hardness and reduced melt characteristics. The objective of the current study was to evaluate the effect of xylitol on the functional properties of low-fat PC. Three different low-fat PC formulations were prepared with 0% (control), 2%, and 4% xylitol. All 3 PC formulations were formulated to contain 5% fat, and each treatment was manufactured in triplicate. Rheological characteristics including elastic modulus, viscous modulus, and temperature at Tanδ = 1 (melt temperature) were determined using dynamic stress rheometry (DSR). The DSR was carried out at a frequency of 1.5 Hz and stress levels of 400 Pa, using a temperature sweep from 20 to 90°C. The hardness of the samples was determined by using texture profile analysis (TPA). Compositional analysis indicated that all treatments had similar fat, protein, and moisture contents. Elastic and viscous moduli results obtained with DSR showed a significant difference between 0% xylitol (control) and xylitol-containing treatments in the temperature range of 30 to 80°C. The melt temperature was not significantly different between the 3 treatments. However, TPA demonstrated that the addition of xylitol significantly decreased the hardness of low-fat PC. Based on TPA and DSR data obtained in this study, we determined that xylitol addition improved the functional properties of low-fat PC.
Key words: process cheese, low fat, xylitol

INTRODUCTION

Process cheese (**PC**) is a dairy food prepared by blending natural cheese, sodium chloride, emulsifying salts, and other dairy and nondairy ingredients, and then heating with continuous agitation to produce a pasteurized product that is homogeneous and has an extended shelf life (Meyer, 1973; Thomas, 1973; Kapoor and Metzger, 2008). Process cheese or process cheese products utilize nearly one-third of all natural cheese produced in the United States. Process cheese is one of the leading varieties of cheese in the world and is used as an ingredient in various food preparations (Sorensen, 2001; Kapoor and Metzger, 2008). Process cheese is manufactured in a variety of forms such as slices, loaves, shreds, and spreads.

In the United States, the Code of Federal Regulations (**CFR**) legally defines 3 categories of PC based on the requirements for minimum fat content, maximum moisture content, and minimum pH, as well as the quantity and number of optional ingredients that can be used (FDA, 2008a; 21CFR133.169 to 133.180). A full-fat PC must contain a minimum of 30% butter fat. This substantial quantity of fat plays an important role in its melting characteristics (Subramanian et al., 2006). Even though fat plays a critical role in the overall acceptability of food products, consumer desire low-fat products due to the association of excess fat intake with heart disease and obesity. Cheese is one of the major contributors of dietary fat in America. Hence, efforts have been made to reduce the fat content in natural and process cheeses (Drake et al., 1999).

According to the CFR, the fat content in a reduced-fat PC should be at least 25% less (FDA, 2008b; 21CFR130.10) than that of its conventional counterpart (that contains a minimum of 30% fat). To achieve the claim of a low-fat PC, the fat content in low-fat PC must be less than 6 g/100 g of PC (FDA, 2008c; 21CFR101.62). Consequently, to meet the low-fat requirement, an 80% reduction in fat relative to full-fat PC is required.

Manufacture of reduced- or low-fat PC is a challenge to the dairy industry because acceptance of the PC largely depends on its functional properties, in which fat content is a critical component. In natural cheese,

Received January 24, 2012.
Accepted June 29, 2012.
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the fat and moisture are entrapped in a 3-dimensional protein network (Prentice, 1987), which gives structure to the cheese. However, in the manufacture of PC, the use of emulsifying salt, heat, and vigorous mixing result in a stabilized emulsion of fat within the protein matrix (Lee et al., 2003; Price, 2007). This phenomenon gives a unique microstructure to PC, which consists of a protein network containing an evenly dispersed fat phase that gives PC its functional characteristics (Kapoor and Metzger, 2008; Johnson et al., 2009). Within the protein matrix, fat plays an important role in cheese texture by providing lubrication (Raval and Mistry, 1999). Consequently, when the fat content of PC is reduced, an increase in the protein network and a decrease in lubrication provided by fat occur, which results in a firm, rubbery texture and poor melting characteristics (McMahon et al., 1996; Zhong, 2003).

Most of the fat in PC is derived from the natural cheese used in its manufacture (Johnson et al., 2009). Hence, utilization of fat-free or nonfat natural cheese lowers the fat content in PC. However, lower fat or nonfat natural cheese is associated with many functional and organoleptic defects, which tend to be carried over into the PC (Muir et al., 1997; Gwartney et al., 2002). The fat in PC can be replaced by adding water, protein, or other additives such as gums and stabilizers (Caric and Kalab, 1993; Lee et al., 2003). The acceptability of low-fat PC can be improved by using fat replacers that partially or fully replace fat and simulate the properties of fat (Jones, 1996; Drake et al., 1999).

Fat replacers are classified according to the substances from which they are derived. Carbohydrate-based fat replacers include pectin, gums, starch, dextrin, vegetable fibers, and carrageenan. Protein-based fat replacers include modified whey protein and soy protein. Lipid-based fat replacers include mono- and diglycerides, olestra, salatrim, and carpenin (Napier, 1997).

Several different fat replacers have been shown to produce reduced-fat PC with improved functional characteristics (Davison and Schwimmer, 1993; Mehnert and Prince, 1996; Drake et al., 1999; Swenson et al., 2000). A study on the physical and sensory properties of reduced-fat PC spread made using hydrocolloid fat mimetics concluded that the texture of 40% reduced-fat PC was comparable to that of full-fat PC (Brummel and Lee, 1990). Drake et al. (1999) reported that 50% reduced-fat PC containing lecithin had improved functional properties (elasticity, firmness, and cohesiveness) relative to a 50% reduced-fat control that contained no lecithin. Hassan et al. (2007) reported that 35% reduced-fat PC produced with reduced-fat Cheddar made from exopolysaccharide (**EPS**)-producing starter cultures had a softer texture compared with a 35% reduced-fat PC control that contained no Cheddar made from EPS-producing starter cultures. All of these studies indicate that the functional properties of PC with up to 50% reduced fat can be improved with the use of fat replacers. However, no study has been conducted to evaluate the functional properties of low-fat (≤6% fat) PC.

Xylitol is a carbohydrate-based, hydrocolloid fat mimetic substance that has not yet been evaluated as a fat replacer in reduced- or low-fat PC. Xylitol is a Food and Drug Administration-approved sugar alcohol that can be used in foods as an ingredient. Xylitol is an intermediate product of carbohydrate metabolism obtained from xylan-containing plant materials (Sandrou and Arvanitoyannis, 2000). Xylitol has also attracted the interest of food scientists for use as a sugar replacer because of its sweetening power and low caloric property. Xylitol is highly hygroscopic in nature and absorbs water in foods (Tomasik, 2003; Mushtaq et al., 2010). The hygroscopic nature of xylitol results in formation of a gel-type texture that provides lubricity, which may improve the texture of low-fat PC. Previous studies on low-fat cookies with added xylitol (Zoulias and Piknis, 2000) have shown improved functional properties. Because the use of xylitol has not been evaluated in low-fat PC, the objective of the current study was to determine the effect of xylitol on the functional properties of low-fat PC.

MATERIALS AND METHODS

Process Cheese Formulations

Three different PC formulations were developed that contained 0% xylitol (control), 2% xylitol, and 4% xylitol. The ingredients used in each formulation are shown in Table 1. The ingredients used were trisodium citrate (KIC Chemical Inc., New Paltz, NY), salt (Cargill, Minneapolis, MN), fat-free Cheddar (Valley Queen Cheese Factory, Milbank, SD), aged Cheddar (Cabot Extra Sharp Cheddar, Cabot, VT), 88% lactic acid (Fisher Scientific, Pittsburgh, PA), sorbic acid (Hawkins Inc., Minneapolis, MN), lactose (Fisher Scientific, Pittsburgh, PA), xylitol (Danisco USA Inc., Thomson, IL) and water. The same blend of fat-free and aged Cheddar cheeses was used for all the treatments and replicates. The primary carbohydrate in PC is lactose and a typical PC formulation will have approximately 4% lactose. In PC, lactose is used as filler and has a minimal effect on the functionality (Kapoor and Metzger, 2008). Consequently, to balance the composition of each formulation, addition of xylitol was compensated by a reduction in lactose: the 0% xylitol