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Functionality of lipase and emulsifiers in low-fat cakes with inulin

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ABSTRACT

The functional effects of lipase (0.003 and 0.006 g/100 g of flour) and emulsifier (0.5 and 1 g/100 g of flour) on fat-replaced (0%, 50% and 70%) batters and cakes with inulin (0, 7.5 and 10 g/100 g/of flour, respectively) were studied. Emulsifier addition significantly lowered the relative density of the batter. Emulsifier incorporation increased the viscoelastic properties of the batter. In contrast, lipase incorporation decreased the degree of system structuring. The evolution of the dynamic moduli and complex viscosity with rising temperatures were studied. Batters with 1 g/100 g emulsifier displayed a significantly lower complex viscosity during heating, resulting in collapsed cakes. Differential scanning calorimetry results revealed that the thermal setting in the control cakes occurred at higher temperatures, and accordingly, greater cake expansion was observed. Cakes with 0.003 g/100 g lipase or 0.5 g/100 g emulsifier displayed volume and crumb cell structure that were similar to those of control cakes. Higher concentrations of both improvers gave rise to cakes with lower volume, higher hardness and lower springiness. During storage time, cakes with lipase displayed lower hardness. Both improvers, at low concentrations, could improve certain physical characteristics, such as crumb structure, of fat-replaced cakes with inulin.

1. Introduction

Consumers are increasingly balancing health concerns with pleasurable eating, which has given rise to a healthier menu movement in quick- and full-service restaurants. Approximately one-third of the best-selling new foods and beverages introduced in 2010–11 carried a natural claim; one-quarter claimed added nutrients/nutrition, high fibre/whole grain, reduced calories or low-fat/fat-free content (Sloan, 2012). A promising way for the food industry to provide advantageous food is to replace fat with dietary fibre (Zahn, Pepke, & Rohm, 2010).

Inulin has been defined as a polydisperse carbohydrate material consisting mainly, if not exclusively, of β-(2-1) fructosyl-fructose links (Roberfroid & Delzenne, 1998). Inulin-type fructans are plant carbohydrates that, because of the β-(2-1) configuration of the fructosyl-fructose glycosidic linkages, resist digestion in the upper gastrointestinal tract, but they are quantitatively fermented in the colon. Therefore, they undoubtedly form part of the dietary fibre complex and must be labelled as dietary fibre on consumer food products (Roberfroid, 2007). Prebiotics are a category of nutritional compounds that are grouped together by their ability to promote the growth of specific beneficial (probiotic) gut bacteria; many dietary fibres, especially soluble fibres, exhibit some prebiotic activity, such as inulin, oligofructose and frutooligosaccharides (Kelly, 2008). Inulin appears to modulate a variety of body functions that are associated with health and well-being. Indeed, it has the potential to reduce the risk of developing osteoporosis, acute and chronic inflammation of the bowel, colorectal cancer and some metabolic disorders associated with obesity (Gibson & Delzenne, 2008).

From a technical point of view, inulin is easy to use, and it also contributes to the desired taste and texture of baked goods and cereals (Niness, 1999). Inulin has been used in several studies to replace fat or improve dietary fibre content in cereal products (Aravind, Sissons, Fellows, Blazek, & Gilbert, 2012; Devereux, Jones, McCormark, & Hunter, 2003; Juszczak et al., 2012; Morris & Morris, 2012; Rodríguez-García, Laguna, Puig, Salvador, & Hernando, 2013; Rodríguez-García, Puig, Salvador, & Hernando, 2012; Zahn et al., 2010; Ziobro, Korus, Juszczak, & Witczak, 2013).

Cake batters are complex emulsions of fat or oil in an aqueous phase containing flour, eggs, sugar and minor ingredients (Sahi, 1999). The fat in cake batter not only helps the incorporation of

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air, but it also produces emulsifying properties and holds considerable amounts of liquid to increase and extend cake softness and "shortens", that is, it interrupts the protein particles to break gluten continuity to tenderise the crumbs (Bennion & Bamford, 1973). Therefore, fat reduction implies major changes, such as reduced volume and increased crumb firmness.

Emulsifiers are widely used within the cake baking industry to help suspend ingredients, incorporate air and provide stability to batter; their use has simplified cake making methods and enables a greater variety of ingredients to be used (Alava, Whitworth, Sahi, & Catterall, 1999). Several studies conducted on the addition of emulsifier to cakes are found in the literature. As the addition of a lipid-like emulsifier to cake systems can affect both the interfacial and bulk properties of batter, Sahi and Alava (2003) worked to improve the understanding of the influence of emulsifiers on both batter and cake properties to optimise recipe formulation and product quality. Khalil (1998) evaluated the effect of fat replacement by carbohydrate-based fat replacers alone and in combination with an emulsifier on batter, cake characteristics and sensory properties. Kim and Walker (1992) determined the effects of additional emulsifiers and other ingredients, such as various starches and sugar, on batter and cake quality. Moreover, the emulsifier effect has been studied in cake systems where fat and/or sugar were partially replaced. Kumari, Jeyarani, Soumya, and Indrani (2011) conducted a study to establish the effect of replacing hydrogenated fat with sunflower oil, coconut oil, emulsifiers, and hydrocolloids on the rheological, fatty acid profile and quality characteristics of pound cakes.

Other studies have been conducted to develop and apply other improvers to enhance the manufacture and quality characteristics of bakery goods. The lipase enzyme has been used to improve some characteristics of breads, such as volume, texture and shelf-life (Katina, Salmenkallio-Marttila, Partanen, Forssell, & Autio, 2006; Moayedallaie, Mirzaei, & Paterson, 2010; Stojceska & Ainsworth, 2008). However, few works in the literature report on the use of enzymes in cake making. Lipase has been applied to improve the performance of cakes using the surfactants produced by lipase to replace emulsifier additives. A commercial lipase enzyme was added in a high-ratio cake (Guy & Sahi, 2006); the lipase enzyme reduced surface tension and surface viscosity at the air/water interface of the batter. Moreover, the surfactants stabilised the bubbles to produce greater overall expansion, cake-specific volume and fine crumb texture. The replacement of emulsifiers with enzymes will be beneficial for those companies preferring to reduce additives (E-numbers) in their products.

The objective of this work was to improve cake quality by incorporating a commercial emulsifier mix and a lipase into cake batters in which fat was replaced with inulin. A number of rheological properties were studied.

2. Materials and methods

2.1. Ingredients

The ingredients used in the preparation of the cake batters were golden dawn plain white flour (ADM Milling Ltd., Brentwood CM14 4HG, UK; composition: 13.9 g/100 g moisture and 9.7 g/100 g proteins), pasteurised liquid egg yolk and egg white (Framptons Ltd., Shepton Mallet Somerset BA4 5PD, UK), white granulated sugar (British Sugar plc, Sugar Way, Peterborough PE2 9AY, UK), skimmed long life milk (Tesco, UK), sunflower oil (Olympics Oils Ltd., Liverpool, L24 9GS, UK) and Frutafit HD® (a highly dispersible native inulin, Sensus, Roosendaal, The Netherlands; specifications provided by the supplier: average chain length 8–13, 2 kcal/g, sweetness of 10% compared to sugar (100%)). To achieve the proper dispersion of inulin to act as a fat mimetic, the appropriate amounts of water (from skimmed milk) were added on the basis of manufacturer suggestions, for an inulin-to-water ratio of 1–2. The lipase enzyme (TS-E 1367) was supplied by Danisco A/S (Denmark). A commercial emulsifier widely used in current products was chosen: Colco (Aromatic AB, Hertfordshire, SG5 3JH, UK), which is a vegetable all-round alpha-gel emulsifier composed of glycerol monostearate (GMS; E471) and polyglycerol esters of fatty acids (PGE; E475). Sodium bicarbonate (Brunner Mond, Cheshire, CW8 4DT, UK), citric acid (VWR International Ltd.; Poole, BH15 1TD, UK), and salt were also used.

2.2. Batter and cake preparation

The batters were prepared with the following ingredients (quantities given on flour basis: g/100 g of flour): wheat flour 100 g, egg yolk 27 g/100 g, egg white 54 g/100 g, sugar 100 g/100 g, sodium bicarbonate 4 g/100 g, citric acid 3 g/100 g, and salt 1.5 g/100 g. Skimmed milk, sunflower oil and inulin (Frutafit HD®) were also added. Moreover, the effect of lipase addition of 0.003 g/100 g (designated L1) and 0.006 g/100 g (designated L2) and emulsifier addition of 0.5 g/100 g (designated E1) and 1 g/100 g (designated E2) were studied on formulations where fat was replaced at three levels, 0%, 50% and 70% (Table 1). A batter without improvers was also studied (designated 0).

The ingredients were weighed out and allowed to reach a temperature of approximately 20 °C. The liquid egg and milk were placed in a Hobart N50 mixer (Hobart Manufacturing Company Ltd., London, UK). The enzyme powder with the flour and the other dry ingredients were blended, sieved and added into the mixer. Finally, the oil was placed on the top, and the mixing was performed with a whipping accessory at speed 1 (60 rpm) for 30 s, followed by 60 s at speed 2 (124 rpm) and continued at speed 3 (255 rpm) for 180 s. A number of measurements were conducted on the batters, including relative density, batter rheology, and differential scanning calorimetry analyses. Two replicates of the same formulation were prepared on different days.

The batter was scaled at 300 g and baked in paper cases placed in 400 g bread tins (145 mm × 75 mm at the base) in a Bone Reel oven (Frederick Bone & Co. Ltd., Purley, UK) for 45 min, at a set oven temperature of 180 °C. Eleven sponge cakes were baked for each formulation in duplicate. The baked products were cooled at room temperature and sealed in polypropylene bags. After 24 h, the sponge cakes were analysed for their weight, volume, crumb cellular structure, texture, moisture content, and water activity. The last three tests were conducted within 24 h after baking and repeated after 7 days and 14 days of storage at 20 °C and a relative humidity 65% to study ageing phenomena.

2.3. Relative density of the batter

The relative density (RD) of the batter was measured with a calibrated density cup of known volume. After mixing, the cup was filled with batter just up to brim level, and then the filled cup was weighed. The same procedure was conducted with water as the filler. The RD was determined gravimetrically by dividing the weight of this known volume of batter by the weight of an equal volume of water. Measurements were performed in duplicate.

2.4. Rheological properties

The rheological properties of the batters were measured using a rheometer (Rheometrics ARES model, TA Instruments Ltd., Crawley, UK). The measurements were taken straight after mixing, using a 50 mm diameter parallel plate. The strain was selected by