Journal of Cereal Science 53 (2011) 19–24

Contents lists available at ScienceDirect

Journal of Cereal Science

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

Effects of glycerol on water properties and steaming performance of prefermented frozen dough

Liqun Huang [a], Jingjing Wan [a], Weining Huang [a,*], Patricia Rayas-Duarte [b], Gang Liu [c]

[a] The State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu 214122, China
[b] Robert M. Kerr Food & Agricultural Products Center, Oklahoma State University, Stillwater, OK 74078-6055, USA
[c] Hangzhou Zhiwei Foods Co., Ltd., Hangzhou, Zhejiang, 311107, China

ARTICLE INFO

Article history:
Received 7 December 2009
Received in revised form
19 May 2010
Accepted 9 July 2010

Keywords:
Prefermented frozen dough steamed bread
Glycerol
Water properties
Differential scanning calorimetry (DSC)

ABSTRACT

The amount of ice in both unfrozen steamed bread dough (UFD) and prefermented frozen steamed bread dough (PFD) with and without glycerol was investigated by differential scanning calorimetry (DSC). The quality of unfrozen steamed bread (UFB)/prefermented frozen dough steamed bread (PFB) was also evaluated. Frozen stability and steaming performance of prefermented frozen dough were negatively correlated with ice crystal growth. Glycerol effectively prevented the formation of ice crystals during freezing and frozen storage, maintaining the quality of steamed bread from prefermented frozen dough even over a period of 30 days. The best steamed bread performance was observed with the dough containing 2% of glycerol (flour weight basis) addition. Prefermenting conditions significantly affected the quality of UFB/PFB. The highest quality scores of steamed bread from prefermented frozen dough were obtained from 32 °C and 85% rh for 40 min.

1. Introduction

The use of frozen dough has been of great interest since the 1960s, and it is now gradually emerging in Chinese bakery chains and traditional food chain stores. Compared to freshly baked bread, frozen dough bread requires longer proof time and produces bread with lower specific volume and a relatively harder texture (Huang et al., 2008; Kim et al., 2008; Xu et al., 2009). But the advantages of frozen dough, including constant availability of fresh products, lower costs, and uniform quality (Räsänen, 1998) has increased the use of industrial frozen dough worldwide. Frozen dough is available in two different types, depending on when fermentation takes place. Dough that is fermented after freezing is called non-fermented frozen dough while dough fermented before freezing is referred as prefermented frozen dough. For the most part, non-fermented frozen dough is used in industrial baking. However, prefermented frozen dough has some advantages, including a reduced need for yeast viability after frozen storage, less time-consuming production after freezing and cheaper bake-off stations (Räsänen, 1998). It is better suited to chain stores because it reduces processing time after frozen storage. In fact, prefermented frozen dough can be baked directly so that neither thawing nor proofing is needed after frozen storage. This technology has been termed “ready to bake” or “ovenrise” (Le-Bail et al., 2010).

Only a few studies have been carried out to study the characteristics of the prefermented frozen dough, and to the best of our knowledge no reports on prefermented frozen steamed bread dough (PFD) are found in the literature. Steamed bread is a traditional Chinese fermented food made from medium strength wheat flour with protein content ranging from 9 to 11% (Wang, 1994). The formula for steamed bread is simply flour, water, yeast (or starter) and baking soda, and may sometimes include sugar and/or salt (Huang and Hao, 1993). The relatively low water addition (40–50%, flour weight basis) and gluten content resulted in incomplete gluten matrix formation of steamed bread dough compared to other baked products (Huang, 2003; Huang and Hao, 1993; Rubenthaler et al., 1990). The relatively low cooking temperature and high humidity during steaming led to a dense but white end product with a very short shelf life, which makes frozen dough more appealing for the industrialization of Chinese steamed bread (He and Liu, 2004; Huang and Hao, 1993; Su et al., 2009).

It has been reported that prefermentation time had a pronounced influence on the quality of the final product. (Räsänen, 1998; Räsänen et al., 1995). A decreased amount of water also played an important role in improving prefermented frozen

Abbreviations: DSC, differential scanning calorimetry; FW, freezable water content; PFB, prefermented frozen dough steamed bread; PFD, prefermented frozen steamed bread dough; UFB, unfrozen steamed bread; UFD, unfrozen steamed bread dough; W_t, total amount of water.

* Corresponding author. Tel./fax: +86 510 8591 9139.
E-mail address: wnhuang@jiangnan.edu.cn (W. Huang).

0733-5210/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcs.2010.07.006

dough. Reduced water content enhanced the fermentation stability, bread form ratio and specific volume (Räsänen et al., 1997b). Studies on water distribution (^{1}H NMR) showed that the negative effects of ice crystals could be controlled by reducing the water content. Reduced water content and the combination of an emulsifier and shorter prefermentation time improved the water distribution of frozen prefermented dough (Räsänen et al., 1997a, 1998). Baier-Schenk et al. (2005) also focused on the effect of ice in prefermented frozen bread dough. Their study concluded that the redistribution of water during frozen storage allowed ice crystal formation and reduced the baking performance of the prefermented frozen dough.

Differential scanning calorimetry (DSC) is frequently used for determining the mass of water that freezes during the cooling of aqueous solutions of polymers, proteins, suspensions of liposomes and biological tissues (Bronshteyn and Steponkus, 1993). DSC has also been widely utilized to determine the effects of freezing/frozen storage and additives on the thermo-mechanical behavior of bread dough (Baier-Schenk et al., 2005; Bot, 2003; Matuda et al., 2005, 2008; Ribotta and Le-Bail, 2007; Sharadanant and Khan, 2003), bread crumbs (Baik and Chinachoti, 2001; Jiang et al., 2008) and corn tortillas (Clubbs et al., 2008; Vittadini et al., 2004) at sub-freezing temperatures. Only one single endothermic peak was centered around 273 K (0 °C) in gelatin samples with various water contents. The melting peak at lower temperature was attributed to intermediate water and the peak at higher temperature was assigned to free water (Liu and Yao, 2001). Addition of carboxymethyl cellulose, gum arabic, kappa carrageenan, and locust bean gum to dough lowered the ΔH value, indicating a decrease in freezable water (Sharadanant and Khan, 2003). Dough with a combination of ascorbic acid and hemicellulase contained a higher amount of water that was unable to crystallize and showed lower cooperativity in the ice-melting transition, indicating more polymer-water interactions (Ribotta and Le-Bail, 2007). Vegetable shortening and emulsifiers did not significantly influence the unfrozen water content (Matuda et al., 2005).

Glycerol has a cryoprotectant activity similar to trehalose (Izawa et al., 2004b). Addition of glycerol to baker's yeast resulted in improved dough leavening capacity, reduced proof time after initial freezing and thawing, and improved freeze–thaw stress tolerance, suggesting the potential of using intracellular-glycerol-enriched cells in frozen dough (Izawa et al., 2004a,b; Myers and Attfield, 1999). Flour properties and firming rate of breads appeared to be affected by glycerol. Glycerol (1%, flour weight basis) conveyed stability to the dough, producing the least changes in alveographic properties during freeze-thaw cycles (Yadav et al., 2008). Glycerol/salt combinations helped control the stiffness of corn tortillas (Clubbs et al., 2008). In bread, Baik and Chinachoti (2003) showed increased structural rigidity and more rapid firming of the glycerol-added samples, even with less amylopectin recrystallization compared to the control. As to water-related properties, studies have shown that glycerol/salt combinations significantly decreased the freezable water content in tortillas and helped control water homogeneity and distribution during storage (Clubbs et al., 2008; Vittadini et al., 2004). The crystallization proceeded in two clearly distinguished steps. The first step was associated with a large enthalpy change and was attributable to crystallization into two-dimensionally ordered structures (Inaba and Andersson, 2007). The main transition (near 0 °C) shifted to a lower temperature with added glycerol due to freezing point depression. The low-temperature transition (−50 °C), found only in high-glycerol (8.8%) bread, suggested excess or phase-separated glycerol (Baik and Chinachoti, 2001).

In this study, prefermented frozen dough was employed in a steamed bread dough system and DSC was used to determine the effect of glycerol on distribution of ice in prefermented frozen steamed bread dough (PFD). The objective of this work was to investigate the influence of glycerol on the water properties of PFD and on the quality of steamed breads.

2. Materials and methods

2.1. Materials

Commercial steamed bread flour was purchased from Danyang Tongle Flour Co., Ltd., (Danyang, China). Moisture, ash, and protein content (13.4, 0.47, and 11.6% at 14% moisture basis, respectively) were determined using Approved Methods 44-15A, 08-01, and 46-12 (AACC International, 2000). Glycerol (Kerry Oils & Grains Co., Ltd., Shanghai, China), shortening (Fortune, China), yeast cream (Yanshan, Hebei, China), sugar, and salt were acquired from a local market in Wuxi, China.

2.2. Prefermented frozen steamed bread dough production

The formulation used for PFD is shown in Table 1. The glycerol levels were selected from data obtained with preliminary experiments. Flour, yeast cream, glycerol and water were mixed (A120t Mixer, Hobart Corporation, Troy, Ohio, USA) at low speed for 2 min and at high for 7 min to achieve complete development. After mixing, the dough was divided into 75-g pieces, molded, and prefermented in four separate groups: 32 °C and 85% rh for 30 min; 32 °C and 85% rh for 40 min; 38 °C and 85% rh for 30 min and 38 °C and 85% rh for 40 min. These conditions were selected from preliminary experiments. The dough was packed into polyethylene bags, immediately frozen at −35 °C and stored at −18 °C for up to 30 days.

After 3, 7, 14, 21 and 30 days of frozen storage, doughs were removed from the freezer, and steamed directly in bamboo steamers for 15 min. Analysis of UFB/UFD samples included DSC, water content and scoring of quality parameters.

2.3. Moisture content

Moisture contents of the PFD/UFD samples were determined by Approved Methods 44-15A (AACC International, 2000). This analysis provided the total amount of water (W_t) in the dough. Moisture content analyses were carried out at least in duplicate.

2.4. Thermal analysis

Samples (about 5 mg) of PFD/UFD were placed in a hermetically sealed aluminum pan and analyzed with a DSC (Pyris 1 DSC, PerkinElmer, Ltd., USA). An empty pan was used as reference. Samples were heated at 5 °C/min from −40 °C to 20 °C. Analyses were performed at least in duplicate. FW was obtained from the endothermic melting peak around 0 °C corresponding to ice melting.

Table 1
Formulation of prefermented frozen steamed bread dough containing glycerol additions.

Ingredient (g)	Control[a]	Glycerol 2%[b]	Glycerol 3%[b]	Glycerol 4%[b]
Wheat flour	300	300	300	300
Water	138	138	138	138
Yeast	7.5	7.5	7.5	7.5
Glycerol	0	6	9	12

[a] Control: dough without glycerol.
[b] Dough with 2, 3 and 4% glycerol addition (flour weight basis).