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Research Article

Effect of Stirring Time, Proofing Time and Water Content on the Aging of Steamed Bread

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Abstract: The effect of stirring time, fermentation time and moisture content on staling of steamed bread were studied. The absorbance, Aw and their correlations for different mixing time steamed bread were measured. The absorbance of steamed bread with different fermentation time was described after cold storage for 72 h. In addition, the effect of moisture content on the microstructure of steamed bread was analyzed by Scanning Electron Microscopy (SEM) and the staling rate was quantified by DSC and absorbance. The result shows that the staling rate of steamed bread increased with the moisture content. It also indicates that the staling rate of steamed bread is affected by mixing time and related to Aw. Besides, fermentation time also has an effect on the staling rate of steamed bread.

Keywords: Absorbance, DSC, microstructure, steamed bread, staling, staling rate

INTRODUCTION

As a traditional staple, Chinese steamed bread or bun (Mantou in Chinese) plays an important role in daily life. Steamed bread is usually prepared from wheat flour and water as core materials combined with instant dry yeast as a starter (AQSIQ, 2007) through fermentation method. Although it is named as bread, the cooking way of steamed bread is not baking but steaming. The fresh steamed bread exhibits white and smooth appearance, slightly sweet taste and good elasticity. During the storage, similar to other bakery products such as bread and cakes (Piazza and Masi, 1995; Lent and Grant, 2001), it, however, is prone to staling which leads hardness increasing and texture loosing. Previous research (Ping *et al*., 2005) reported that the main cause of staling of steamed bread is the interaction between starch and protein (mainly wheat gluten). Sha *et al*. (2007) pointed out that the main factor of aging of steamed bread is starch staling. This conlusion is consistent with the result that starch is the main reason for the bread aging studied by Rao *et al*. (1992) and Roach and Hoseney (1995). And Furthermore, t starch staling are highly related with moisture content, temperature, lipid molecules, sugar and other additives of steam bread (Longton and Legrys, 1981; Lu *et al*., 1997; Marston and Short, 1969; Zeleznak and Hoseney, 1987). Besides, stirring time and proofing maturity influence quality and aging of steamed bread as well. The aim of this study was, therefore, to analyze effects of stirring time, proofing time and moisture content on the aging of steamed bread.

MATERIALS AND METHODS

Steamed bread processing: Commercial wheat flour was purchased from local market. Instant dry yeast was used as a starter. The steamed bread recipe consists of wheat flour (1.0 kg), instant dry yeast (2%, flour basis) and water (49%, 37°C flour basis). Peng (2012) Instant dry yeast was well dissolved in water for 5 minutes and then poured into wheat flour. Ingredients were mixed for several min until the surface of dough is smooth. Dough was proofed at 38°C and 85% relative humidity for a period of time, then divided (115 g), kneaded and mechanically rolled to make uniform steam bread doughs. The steam bread dough was consequently steamed by water vapor for 25min.

Stirring time effect on steam bread aging: The ingredients (wheat flour, water and starter) were stirred for 3, 6, 10, 15, 20 and 25 min, respectively. Resulting dough was proofed for 90 min and steamed. The cooked steam bread was cooled at room temperature till temperature of its core decreased to 25ºC. Finally, they were packed in plastic bags and stored at (10±2) °C for 72h. The samples prepared under different conditions were ready for determinations.

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Proofing time effect on steam bread aging: The ingredients were stirred for 10 min and resulting dough was proofed for 0, 20, 40, 60, 80 and 100 min, respectively. At the end, cooked steam bread was cooled at room temperature till their core temperature deceased to 25°C, they were then packed in plastic bags and stored at (10±2) °C for 72h. The samples prepared under different conditions were ready for determinations.

Different moisture contents effect on steam bread aging: All ingredients were stirred for 10 min and resulting dough was proofed for 90 min. The cooked steamed bread was cooled at cold blast air for different time to obtain different moisture contents, then packed in plastic bags and stored at (10±2)°C for 0, 24, 48, 72, 96 and 120 h. The samples prepared under different conditions were ready for determinations.

Water content and activity evaluation: Water content was measured following the standard method 44-15A (AACC, 2000). The sample was obtained from the central part of the steamed bread. Two grams of sample was used for the analysis. Water activity (A_w) analysis was performed in a water activity tester HygroLab2 (Rotronic, Switzerland).

Determination of starch viscosity: The samples (5g) taken from the center of the steamed bread and 25 mL water were mixed in a beaker for 1h, they were then transferred to the centrifuge tube to obtain supernatant using centrifugal machine at 5000 r/min for 10 min (Piazza and Masi, 1995). 1 mL iodine solution, 2 mL supernatant and 25 mL water were put into a 50 mL volumetric flask at 35°C water bath for 15 min and compensate volume to 50 mL, tests were done in triplicates (Zhao *et al*., 2002). Water was used instead of the supernatant in the control group. Measurements of the absorbance (λ = 620 nm)of different steamed bread were taken by spectrophotometer (18 series, Beijingpuxi).

Starch staling determination: A differential scanning calorimeter (DSC-60A, SHIMADZU) was used to determine thermal parameters (onset, peak and endset temperature) and melting enthalpy of starch of steamed bread at ordinary pressure. Steamed bread samples (2.5-4.0 mg) taken from the center were weighted in aluminum pans. An empty aluminum pan was used as a reference. After sealing, aluminum pans were heated from 25 to 220°C at a heating rate of 15°C/min (Koo *et al*., 2005; Rogers *et al*., 1988). The baseline was obtained from a scan with two empty pans. The melting enthalpy of starch was estimated as the area under theDSC baseline. The corresponding thermal parameters were calculated with the software (TA-60WS-DSC) of the calorimetric apparatus from the DSC thermogram.

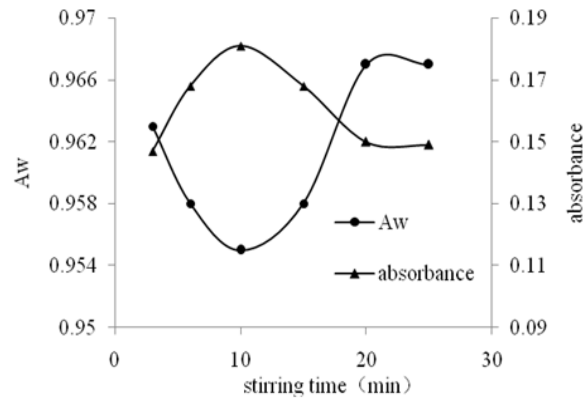

Fig. 1: The primary axis is the trend of change on Aw with the extent of stirring time and the secondary axis is the trend of change on absorbance with the extent of stirring time (The starting point is 3min for it cannot be operated)

Scanning Electron Microscopy (SEM): A JSM-6380 scanning electron microscope (Japan Electronic Co., Ltd.) was used. The steamed bread sample was freeze-dried and cut into pieces (30×8×8 mm). And then, the sample was fixed on the specimen holder by double-side tape and kept natural fracture face up, then coated with gold. Finally, the sample was transferred to the microscope and observed at 15 kV.

RESULTS AND DISCUSSION

Influence of stirring time on water activity (A_w) and absorbance of steamed bread: A_w and absorbance of steamed bread with different stirring time after cold storage for 72h are shown in Fig. 1. From Fig. 1, Aw achieves a minimum value at 10 min stirring time, then increased and stabilized according to mixing time increase. Absorbance shows the opposite pattern and correlation coefficient between Aw and absorbance is 0.929 at the level of 0.01 after analysis by SPASS.

The hydrone and starch molecules were distributed and fully combined with the increase of stirring time, thereby the ratio of free water and bound water decreases as well as Aw. Starch molecules are scattered over the network formed by water molecules and wheat gluten, the network makes the water molecules and starch unable to be combined fully. The combination of these two factors results in that as stirring time increases, the ratio of free water (Aw) tends to rise. Interactions among starch, protein and moisture, consequently, tend to equilibrium when wheat gluten is fully hydrated. Meanwhile, absorbance is inversely proportional to the water activity (Fig. 1), which indicates that lower the Aw, weaker the interactions between water and starch, lower the staling rate of starch.

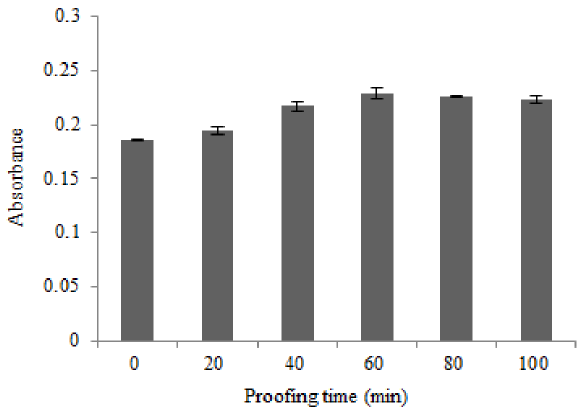

Fig. 2: The figure shows the influence of fermentation time on the absorbance of steamed bread

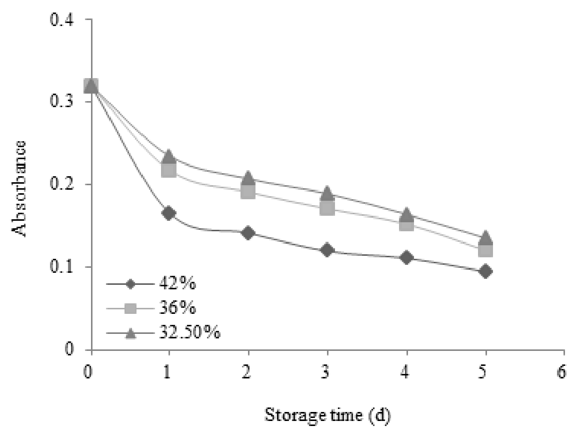

Fig. 3: Retrogradation enthalpy of different moisture content of steamed bread with the extent of the cold storage time (42%, 36%, 32.5% respectively represent the 42%, 36%, 32.5% moisture content of steamed bread.)

Effect of the proofing time on the absorbance of steamed bread: The effect of different proofing time of steamed bread was evaluated after cold storage of 72 h. Figure 2 shows that the absorbance value reached maximum at 60 min proofing time and then slightly decreased in the light of proofing time increase. Unstable gelatinized starch molecules of steamed bread tend to parallel arrangement due to massive hydrogen bonds, which lead to difficulties for water to penetrate into oriented starch, thereby, result in starch staling. The complex structure, consisted by water, starch and gluten, is more and more loose and soft for the gas released by yeast under optimum conditions with the increase of proofing time, it hinders the interactions of starch molecules and hydrone which are spread in the network. Therefore, with the increase of proofing time,starch staling rate will decrease and the absorbance will increase. Over proofing, great amount of gas is, however, able to destroy the gluten network, collapse the stoma, thereby increase starch staling rate. Highly similar conclusion was drawn by previous studies (Ronda *et al*., 2014).

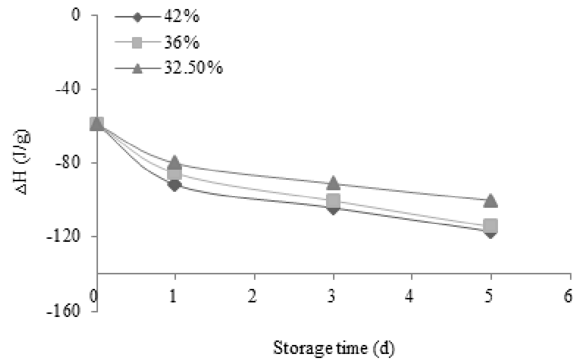

Fig. 4: Retrogradation enthalpy of different water content of steamed bread with the extent of the cold storage time (42%, 36%, 32.5% respectively represent the 42%, 36%, 32.5% moisture content of steamed bread.)

Cold storage time effect on the staling of different-moisture steamed bread: The absorbance of steamed bread with different moisture content was measured during different cold storage time. The absorbance decreased with the extension of storage time (Fig. 3). The absorbance indicates the starch staling rates of different steamed bread: 42%>36%>32.5% (water contents), which is in well line with our actual experience.

Figure 4 shows the retrogradation enthalpy of steamed bread with different water contents. The DSC is a method to evaluate starch staling by measuring the enthalpy of gelatinizing the aging starch. The enthalpy value represents the degree of starch staling, namely the higher absolute value of enthalpy, the higher the degree of aging. The aging degree of steamed bread increases according to the extension of storage time. Moreover, the aging degree tendency of three moisture contents steamed bread is remarkably consistent with those of absorbance of steamed bread with different moisture contents due to starch recrystallization during cold storage (Ronda *et al*., 2011).

Effect of different moisture contents on the microstructure of steamed bread: Figure 5 shows SEM images of the different moisture content steamed bread after 72h cold storage. The starch crystal structure will be gelatinized that origenal crystal breaksup into single molecule and conglutinated together closely in the process of steaming. After starch staling,the gelatinized starch has been destroyed and gradually formed gaps among microcrystalline starch. From Fig. 5, it is clearly observed that huge and massive cracksamong starch aggregates in 42% moisture content steamed bread, but 36% one shows less and barely nocracks exists in 32.5% one. Thus, we

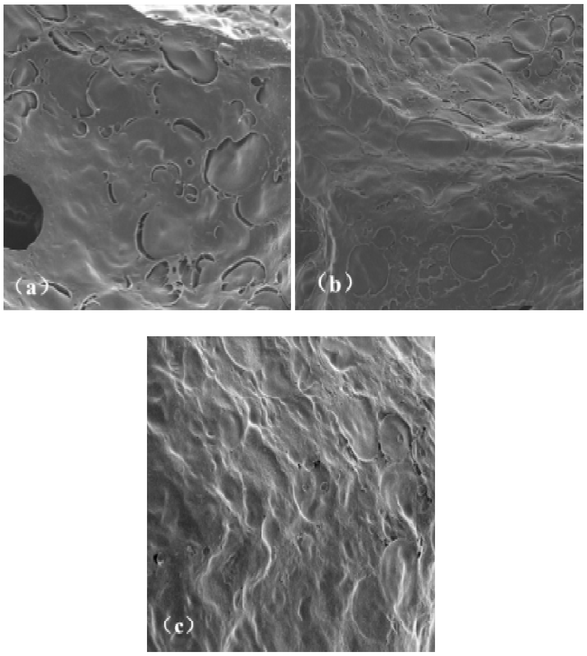

Fig. 5: SEM micrographs of different moisture content of steamed bread after cold storage for 3 days; (a): is 42% moisture content of amed bread; (b): is 36% moisture content; (c): is 32.5% moisture content of steamed bread

summarize that higher moisture content steamd bread shows greater and more cracks among starch aggragates, which lead to higher starch retrogradation rate.

CONCLUSION

We conclude that the optimal stirring and proofing time are confirmed as 10 and 60 min, respectively, due to starch molecules relatively better distributed (low re-arrangement) in gluten network under the conditions. Meanwhile, steamed bread increases aging degree according to cold storage time extension. Moreover, higher moisture content steamed bread exhibites greater aging rate due to huge cracks or gaps among starch crystals which are observed from SEM images. This study, therefore, shows that the stirring time, proofing time and cold storage time have significant effects on steamed aging process and the results can be used to improve quality of steamed bread.

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