Effect of Transglutaminase on the Quality of Gluten-free Grain Steamed Buns

Li Donghong 1, Zhou Dayu 2, Zhu Lijie 2, Yang Lina 2, Ma Tao 1,*

College of Food Science and Technology, Bohai University Jinzhou, Liaoning, 121013, China

1 Author: Li Donghong, E-mail: ly15702413995@163.com
* Corresponding author: Ma Tao, E-mail: matao-09@163.com

Abstract Gluten-free steamed buns were made from rice flour and soybean flour with transglutaminase (TG enzyme) as additives to investigate the effect of TG enzyme on the quality of steamed buns. The results showed that when the TG enzyme dosage was 2.0%, the steamed buns had a lower hardness of 5458.43 and a larger elasticity of 0.85, at which time the gluten-free grain dough had a higher elasticity and viscosity, and the brightness of the steamed buns was enhanced. With the addition of TG enzymes, the quality of gluten-free grain steamed buns has been improved, which provides a basis for the future research and development of gluten-free grain steamed buns.

1. Introduction
Gluten plays an important role in the production of steamed buns, but in some people, ingesting gluten can cause an immune-mediated disease called celiac disease (CD), so the only effective way to prevent CD is to make the patients have a gluten-free diet[1]. Because gluten-free grain flour is gluten-free, there is a big gap between gluten-free products and wheat products. Thus, using gluten-free grain flour to produce high-quality steamed buns has become a major technical challenge[2-3].

Transglutaminase (TG enzyme) is a polymerizer, which can improve the nutritional value of proteins without changing the functional characteristics of proteins, and is widely used in the development of gluten-free products[4]. It was added to the production of gluten-free grain steamed buns to explore the influence of different addition amounts on the quality of the buns, in order to provide a basis for the research and development of gluten-free grain steamed buns.

2. Materials and methods

2.1 Materials
Soybean flour (26.2% protein, 6.0% fat, 41.2% carbohydrate, 11.0% water moisture) and Rice flour (7.9% protein, 7.5% fat, 70.1% carbohydrates, 11.8% moisture) were provided by Shandong Merlot food co. LTD. Transglutaminase (enzyme activity is 100,000 U/g) was provided by East Saint Biotechnology co. LTD, and the addition levels were 0.5%, 1.0%, 1.5%, 2.0% and 2.5% (w/w, flour basis) for it. Soybean flour and rice flour after the mix and twice fermentation were used for the dough and steamed bread.
2.2 Preparation of the dough and steamed bread
Basic formula of plain gluten-free steamed bread: soybean flour (60 g), rice flour (40 g), baking soda (1.3 g), yeast (0.6 g), baking powder (0.6 g), water (60 g).

Production process of gluten-free cereal steamed bread: Raw material powder (40.0g rice flour and soybean flour 60.0g) → Water mixing → Stirring → Primary fermentation (Alkaline protease; pH = 8.0; 60min) → Secondary fermentation (Lactobacillus plantarum; pH = 6.5, TG enzyme; 90min) → Segmentation → Kneading → Molded and fermented → Steaming → Cooling → Finished product

2.3 Gluten-free grain steamed buns texture tests
The steamed bun core (20 mm×20 mm×20 mm) was taken and cooled at room temperature for 1 h. The hardness, elasticity, adhesion, cohesiveness, chewiness and recovery of the steamed bun were measured by the texture analyzer (Stable Micro System, UK). The test parameters were as follows: a compression rate is 50%; a speed is 1mm; a trigger force is 0.05N; a residence time of the two compression processes is 10 s; and the probe is P50\[5\].

2.4 Rheological properties of dough
Dynamic rheological measurement was performed by rheometer (Discovery HR-1 American TA company), fermented (2 g) dough was collected and determined by with 40 mm parallel plate probe. A gap was 1 mm; the temperature was 25 ℃; the frequency was 0.1-10 Hz; and the strain was 0.2%. The elastic modulus (G') and the viscous modulus (G") were measured respectively to evaluate their rheological characteristics\[6\].

2.5 Color measurements
Five samples (diameter of 15 mm) were taken from the center of the steamed bread for color measurement. Color measurement was performed by using the colorimeter (X-Rite Co., USA), and color difference evaluation was performed according to the CIE L*a*b* scale\[7\].

2.6 Statistical analysis
The experimental data were expressed as mean ± standard error with three parallel experiments. The charts were processed by Origin 8.5 software. The significance of the differences was analyzed by SPSS 19.0.

3. Results and discussion

3.1 Texture profile analysis of gluten-free grain steamed buns
According to the above operation, wheat flour steamed bun was used as the control group. 0.5%, 1.0%, 1.5%, 2.0% and 2.5% TG enzymes were added to the dough (TG enzymes were added based on rice flour and soybean flour), as showed in table 1, the texture characteristics were determined.

Table 1. Influence of TG Enzyme Addition on Quality and Sensory Score of Gluten-free Grain Steamed Buns

| TG Enzyme Addition level (%) | Hardness | Elasticity | Adhesion | Cohesiveness | Chewiness | Recovery |
|-----------------------------|----------|------------|----------|--------------|-----------|----------|
| 0.5                        | 8684.35±270.41a | 0.75±0.01c | 0.66±0.03a | 4603.27±122.97ab | 4508.68±785.26a | 0.32±0.03a |
| 1.0                        | 8475.15±98.89a | 0.79±0.00b | 0.57±0.00c | 4848.32±46.15ab | 4306.56±725.17ab | 0.25±0.00b |
| 1.5                        | 6482.51±1149.17b | 0.84±0.02a | 0.60±0.01bc | 5113.76±760.52a | 3830.66±43.07ab | 0.27±0.01bc |
| 2.0                        | 5458.43±415.89c | 0.85±0.02a | 0.64±0.03bc | 5742.84±993.29b | 3443.31±186.55b | 0.27±0.05bc |
| 2.5                        | 7244.41±158.19abc | 0.78±0.00b | 0.62±0.03abc | 3775.79±609.11b | 3608.37±75.51b | 0.31±0.01abc |
| Control                    | 2967.02±132c | 0.99±0.01d | 0.76±0.02d | 7074.55±134.28 | 2130.54±214c | 0.34±0.00d |
It can be known from Table 1 that with the increase of the amount of TG enzyme added, and the hardness of the steamed bread first decreased and then rose, but the chewability gradually decreased and then stabilized, and its elasticity showed a relatively stable trend. When the amount of TG enzyme were 1.5%, 2.0%, 2.5%, the hardness is 6482.51, 5548.43, 72244.41. When the TG enzyme was added at 2.0% of the mixed flour, the texture characteristics of the gluten-free grain buns were closest to those of the control wheat flour buns.

During the fermentation process of the dough, TG enzymes played a role in promoting the cross-linking of proteins, which increased the strength of the network structure of the protein and enhanced the gas-holding property, which was conducive to the formation of steamed bread[8]. As the amount of TG added increased, and the amount of water absorbed became larger, then the viscosity of the dough increased, and the fermentation performance decreases, but the elasticity was less.

3.2 Rheological measurement of dough

![Diagram of dough rheological properties](image)

**FIG 1. Effect of TG Enzyme Addition on Rheological Properties of Dough**

As showed in Figure 1, the addition of TG enzyme showed distinct effects on both the elastic (G') and viscous (G'') modulus. When the amount of TG enzyme added is 2.0% and 2.5%, the dough has higher elasticity and viscosity. As the amount of TG enzyme added increases, the viscosity and elasticity increase, which promotes the internal structure of protein cross-linking is enhanced. Taking economic factors into consideration, 2.0% was selected as the suitable addition amount of TG enzyme.

**Table 2. Influence of TG Enzyme Addition on color Difference of Steamed Bread**

| TG enzyme addition level (%) | L*       | a*        | b*        | △E*      |
|-----------------------------|----------|-----------|-----------|----------|
| 0.5                         | 52.67±0.64bc | 0.68±0.44a | 32.23±0.12b | 48.96±0.61b |
| 1.0                         | 51.42±0.94c  | 0.58±0.28a | 31.31±0.04c | 49.74±0.69ab |
| 1.5                         | 51.72±0.24abc | 0.74±0.14a | 32.40±0.33b | 50.15±0.51a  |
| 2.0                         | 53.78±0.23c   | 0.59±0.12a | 32.36±0.20b | 47.80±0.55c  |
| 2.5                         | 52.32±0.22bc  | 0.71±0.12a | 33.50±0.22a | 49.90±0.27ab |
| Control                     | 83.42±2.13c   | -1.28±0.05a | 15.72±0.24d | -        |

3.3 Color of gluten-free grain steamed buns

The color difference meter can accurately reflect the color change of the steamed bread, where L* value represent the brightness, a * value represent from redness to greenness, b * value represent from blueness to yellowness, and the △E value became larger, indicated that the steamed bread color Dim gradually[9].
Addition of TG enzymes changes the color of gluten-free cereal buns, when the TG enzyme was added at 2.0%, the red, green and yellow-blue degrees did not change significantly, and the brightness and whiteness were mainly improved. \( \Delta E \) value of 47.80 is the lowest among all samples, indicated that the steamed buns are fairer at this time. TG enzyme cross-linking protein structure changed, steamed bread has improved in color[10].

4. Conclusion
In this study, rice flour and soybean flour were used as raw materials to investigate the effects of the amount of TG enzyme added on the texture, rheology, and color difference of steamed bread and dough. The results showed that when the additive amount is 2.0%, and the hardness of the steamed bread was small, and the elasticity was relatively large. When the addition amount was 2.0% and 2.5%, the dough has higher elasticity and viscosity. TG enzyme had little effect on the color of steamed buns and mainly improved the brightness. Comprehensive analysis showed that when the amount of TG enzyme was 2.0%, and the quality of gluten-free cereal steamed bread can be improved.

Acknowledgement
This study (Effect of Transglutaminase on the Quality of Gluten-free Grain Steamed Buns) was supported by the Program of Key R&D Program of Liaoning province (No. 2018205001).

References
[1] H. E. D. La, M. Martinez, and Gómez, Manuel. L.F.S & T 54.1:199-206, (2013).
[2] Pico, Joana, Reguïón, Montserrat P., Bernal, José, & Gómez, Manuel. J.C. S, 86: 92-101, (2019 ).
[3] T.Y. Kang, K.H. Sohn, M.R. Yoon, J.S. Lee & S.Ko. I. J. F. S & T, 50(8):1743-1749, (2015).
[4] C.M. Rosell, & A.Foegeding. F. H, 21(7): 1092-1100, (2007).
[5] E. A. KIM, S.Y. LEE. A.B.C, 59(1): 95-102, (2016).
[6] M.M. MARTINEZ, M. GÓMEZ. J.F.E, 197: 78-86, (2017).
[7] X.R. Kou, D.L.Luo, K.Y. Zhang, W.Xu, X. Li,B.C. Xu, P.Y. Li, S.H. Han, J.X. Liu. F.C, (2019).
[8] K.C.T. MANOJ, L. SABIKHI, A.K. SINGH, P.N. Raju, R. Kumar, R. Sharma. LWT-F.S and T, 103: 19-26, (2019).
[9] O.R. Karin, K.O. Abdulsalam, K.O. Akanji.. J. A.R&D, 11(2):341-347, (2013).
[10] W. Yang, J.Y. Lin, L.Y. Liu, G.Z. Zhang, S.M. Zhou, J. F. S. T, (2016).