Research on Water’S Influences on the Quality of Frozen Dough

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Abstract

The study focuses on the influences of the level of addition, hardness and pH value of the water on the quality the steamed bread with frozen dough. All indicators of steamed bread are evaluated through the single factor experiment and orthogonal experiment, and the results show that all indicators of the steamed bread are best while adding water with pH value at 5, level of addition at 45 ml/100g and hardness at 100 mg/L. The best compositional formulation for specific volume is the water with pH value at 6, level of addition at 45 ml/100g and hardness at 50 mg/L; the best compositional formulation for color is the water with pH value at 6, level of addition at 44 ml/100g and hardness at 100 mg/L; the best compound scheme for surface structure is the water with pH value at 6, level of addition at 44 ml/100g and hardness at 100 mg/L, and the best compositional formulation for softness is the water with pH value at 5, level of addition at 45 ml/100g and hardness at 100 mg/L.

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Keywords: hardness, pH value, level of water addition, frozen dough

1. Introduction

Frozen dough technology develops gradually since 1960s in foreign countries, and it is mainly used for family production at that time. Until 1980s, with booming development of freshly baked bakeries in United States and Western Europe and successive set-up of bakeries in large supermarkets, frozen dough begin to be used widely and put into commercial production. Using frozen dough not only can expand the production scale of bakery, reduce the costs, improve quality of products, but also bring great convenience to consumers, enable them can to enjoy fresh baked bread at home at any time. In addition to being made into bread, frozen dough can also be processed into steam bread, spring roll, steamed stuffed buns, dumplings and other food with Chinese catering characteristics. In recent years, the production of bread-

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leading baked food with frozen dough technology has developed rapidly, and it has become a new
tendency in Chinese baking industry [1]. Many current researches on frozen dough mainly target on bread,
while China can apply these theories in steamed bread to industrialization production of steamed bread.

The chemical compositions of flour are mainly carbohydrate, protein, fat, minerals, water, small amount
of vitamin and enzyme and so on. Among the carbohydrate accounts for about 74% of the weight of flour,
protein for around 12% and water for about 14%. Therefore, beside the carbohydrate and protein, water is
the main material, while the contents of other materials are very low. The role of water and flour during
brewing dough mainly shows in the role of water and protein as well as the role of water and carbohydrate,
so water plays a very important role.

Based on the steamed bread making process with fermented frozen dough and through evaluation on
indications of the quality of steamed bread, this paper studies the influences on the quality of fermented
frozen dough from water with different levels of addition, hardness and PH values, thus putting forward
the process conditions for producing fermented frozen dough suitable for making steamed bread, and this
improves the production level of frozen dough industry in China.

2. Material and Methods

2.1. Experimental material

Flour: Shenxiang special grade 1 flour
Water: distilled water
Calcium chloride: Quancheng Electromechanical & Chemical Industry Co., Ltd.
Magnesium chloride: Tianjin Changlu Haijing Group Co., Ltd.
Citric acid: Zhengzhou Yingchen Chemical Industry Co., Ltd.
Sodium carbonate: Guangzhou Gengda Trading Co., Ltd.

2.2. Experimental apparatus and equipment

a) Refrigerator: manufactured by Henan Xinfei Co., Ltd.
b) Tray medical balance: DP-1: Desoutter GYT-1. Shanghai Medical Laser Equipment. Factory.
c) Ementing box: Fengchu Machinery Factory
d) Colortest: Tianjin jinfulun technology Co., Ltd.
Others: platform balance; analytical balance; basin; micrometric scale; beaker; graduated cylinder;
chopsticks; fermenting box; saucepan.

2.3. Formula and technological process

a) Technological process

Water and flour (100g), yeast (0.8g) → dough mixing → forming → dough recovery (30 °C, 15 min)
→ freezing and cold storage → thawing (30 min) → cooking (20 min) → cooling (3h) → measurement
and rating[2].

2.4. Experimental methods

a) Specific volume

Volume is measured by rapeseed displacer and weight is weighed by table balance.
b) Aspect ratio
It is measured twice with a vernier caliper from different angles, average value is chose when the difference is less than or equal to 0.2 centimeter, and re-determination shall be carried out when it is more than 0.2 centimeter.

2.5. Evaluation criterion and methods

a) Organoleptic evaluation criterion

Beveled the steamed breda into eight pieces, the steamed bread is tasted and rated by multi-persons. The detail of organoleptic evaluation criterion is shown in table 1.

Table 1  Steamed bread organoleptic evaluation criterion

| Item                  | Full marks | Evaluation criterion                                                                 |
|-----------------------|------------|---------------------------------------------------------------------------------------|
| Specific volume       | 20         | It is of full marks when specific volume is more than or equal to 2.8, one mark is diminished for every drop of 0.1, and the lowest mark is 2 marks when specific volume is less than or equal to 1.5. |
| Aspect ratio          | 5          | Aspet ratio is 0.66-0.70, 5marks is scored; aspet ratio is 0.61-0.65, 4marks is scored; aspet ratio is 0.56-0.60, 3marks is scored; aspet ratio is 0.51-0.55, 2marks is scored aspet ratio is 0.45-0.50, 1marks is scored; |
| Color                 | 10         | White and milky white, 8-10 marks; Light yellow, yellow, 6-7 marks; grey dark, 2-5 marks |
| Surface structure     | 10         | Smooth, 8-10 marks; slight vapor bubble, 6-7 marks; crimple and sink, surface burn, 2-5 marks |
| Internal structure    | 15         | Stoma is fine and even, 12-15 marks; stoma is too close grained but even, 10-12 marks; with large stoma and rough structure, 5-9 marks |
| Softness              | 10         | Easy to press, and fell soft, 7-10 marks; difficult to press and very hard, 3-6 marks |
| Elasticity            | 10         | Recovery is good with fingers, 8-10 marks; recovery is good, slow re-bound, 6-7 mark; recovery is poor, 3-5 marks. |
| Chewy performance     | 15         | Strong chew and without dental adhesive, 10-15 marks; weak chewy, dregs, dry and hard, 5-9 marks |
| Odor                  | 5          | Have wheat faint scent, no off- flavour, 4-5 marks; have off-flavour, 1-3 marks |
| Total score           | 100        |

3. Results and analysis

3.1. Single factor experiment

a) Basic indicators of flour

Basic indicators of flour in table 2.

Table 2  Basic indicators of flour

| water/% | wet gluten content /% | ash/% | proteincontent /% |
|---------|-----------------------|-------|-------------------|
| 11.9    | 32.4                  | 0.53  | 10.25             |

b) Influence of level of water addition on quality of steamed bread

The influence of level of water addition on the quality of frozen dough is shown in table 3.
It can be seen that as water addition increases, the index of the specific volume, aspect ratio and internal structure of finished steamed bread show tendency of increasing first and then decreasing, and the overall evaluation of steamed bread is the highest with water addition at 45ml/100g. When water addition is over 45ml/100g, organoleptic rating of steamed bread falls. The level of water addition mainly depends on the blotting capacity of the flour being used. Generally speaking, the less water addition while making frozen dough is, the slower the speed of forming ice crystal and the fewer amount of ice crystal will be, so as to do less damage to dough and the quality of steamed bread finally made will be better.

c) Influence of water hardness on quality of steamed bread

The influence of water hardness on quality of steamed bread is shown in table 4.

It can be seen that with the increase of water hardness, there are improvement of steamed bread in specific volume, aspect ratio, color, structure, softness and other aspects. When the hardness reaches 100mg/L, the organoleptic rating is highest and the internal of steamed bread is brighter with close stoma, good taste and good elasticity. With the increase of hardness, the calcium and magnesium ions will increase accordingly, which would improve the network structure of gluten and starch and this is conductive to the formation of dough. However, excessive hardness will result in hard dough and bad structure, thus affect the quality of steamed bread [4].

d) Influence of pH value on quality of steamed bread

The influence of pH value on quality of steamed bread is shown in table 5.

It can be seen from table 5 that pH value has comparatively great influence on all the organoleptic indicators of steamed bread, and when the pH value is at 5-6, the rating score of steamed bread is the highest. Meta acid environment is conductive to the breeding and growth of yeast, and accordingly the aerogenesis will increase and thus the volume of finished steamed bread will increase. When the environment is meta alkaline, the color is in decreasing trend, that is, the steamed bread becomes yellower and yellower and all indicators fall obviously.

3.2. Orthogonal experiment

Through single factor experiment, select three factors including level of addition, pH value and hardness to conduct the three-factor three-level orthogonal experiment. Factor-level table is shown in Table 6, results of experiment are shown in Table 7, analysis on the experimental results is shown in table 8.

Based on the analysis of Table 8, it can be seen that:
The best full score of sensory evaluation to steamed bread is $A_1 \cdot C_2 \cdot B_2$, that is: the pH value of water is 5, hardness is 100 mg/L and the water addition is 45 ml/100g;
The compositional formulation with best specific volume is $A_1 \cdot B_2 \cdot C_1$, that is: the pH value of water is 6, hardness is 50 mg/L and water addition is 45 ml/100g;
That with the best color is $A_2 \cdot C_2 \cdot B_1$, that is: the pH value of water is 6, hardness is 100 mg/L and water addition is 44 ml/100g;
That with the best surface structure is $A_2 \cdot C_2 \cdot B_1$, that is: the pH value of water is 6, hardness is 100 mg/L and water addition is 44 ml/100g;
That with the best softness is $A_1 \cdot C_2 \cdot B_2$, that is: the pH value of water is 5, hardness is 100 mg/L and water addition is 45 ml/100g.

4. Conclusion

Through single factor experiment, it can be seen that, water addition, pH value and hardness improve the sensory evaluation indicator of the finished steamed bread with frozen dough, while the indicators include specific volume, aspect ratio, color shade, surface structure and softness.
When the pH value of water is 5, hardness is 100 mg/L and water addition is 45 ml/100g, the total score of sensory evaluation of steamed bread is best. The compositional formulation with best specific volume is the water with pH value at 6, water addition at 45 ml/100g and hardness at 50 mg/L and; that with the best color is the water with pH value at 6, water addition at 44 ml/100g and hardness at 100 mg/L and; that with the best surface structure is that the water with pH value at 6, water addition at 44 ml/100g and hardness at 100 mg/L; that with the best softness is that the water with pH value at 5, water addition at 45 ml/100g and hardness at 100 mg/L.

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Table 3 Influences of Level of Water Addition on Quality of Steamed Bread

| No. | Lev level of water Addition (ml/100g) | Specific volume | Aspects | Score 20 | Aspect ratio | Score 5 | Color 10 | Surface structure 10 | Internal structure 15 | Softness 10 | Elasticity 10 | Chewy performance 15 | Total score 100 |
|-----|--------------------------------------|-----------------|---------|----------|--------------|---------|-----------|---------------------|---------------------|-------------|----------------|-----------------------|----------------|
| 1   | 43                                   | 2.17            | 0.59    | 3        | 7            | 7       | 12        | 7                   | 8                   | 13          | 5             | 75                    | 100            |
| 2   | 44                                   | 2.29            | 0.62    | 4        | 8            | 8       | 13        | 8                   | 9                   | 14          | 5             | 82                    | 100            |
| 3   | 45                                   | 2.53            | 0.65    | 5        | 9            | 9       | 14        | 9                   | 9                   | 15          | 5             | 92                    | 100            |
| 4   | 46                                   | 2.31            | 0.57    | 3        | 8            | 5       | 12        | 7                   | 6                   | 13          | 5             | 74                    | 100            |
| 5   | 47                                   | 2.40            | 0.51    | 2        | 7            | 4       | 11        | 7                   | 6                   | 14          | 5             | 72                    | 100            |

Table 4 Influence of Water Hardness on Quality of Steamed Bread

| No. | Water hardness (mg/L) | Specific volume | Aspects | Score 20 | Aspect ratio | Score 5 | Color 10 | Surface structure 10 | Internal structure 15 | Softness 10 | Elasticity 10 | Chewy performance 15 | Total score 100 |
|-----|------------------------|-----------------|---------|----------|--------------|---------|-----------|---------------------|---------------------|-------------|----------------|-----------------------|----------------|
| 1   | 0                      | 2.24            | 0.57    | 3        | 6            | 5       | 12        | 7                   | 7                   | 13          | 4             | 71                    | 100            |
| 2   | 50                     | 2.37            | 0.62    | 4        | 7            | 7       | 13        | 8                   | 7                   | 12          | 5             | 78                    | 100            |
| 3   | 100                    | 2.63            | 0.66    | 5        | 8            | 9       | 15        | 9                   | 9                   | 15          | 5             | 93                    | 100            |
| 4   | 150                    | 2.12            | 0.63    | 4        | 7            | 8       | 14        | 8                   | 8                   | 14          | 5             | 80                    | 100            |
| 5   | 200                    | 1.86            | 0.60    | 3        | 5            | 7       | 13        | 8                   | 7                   | 14          | 5             | 72                    | 100            |
Table 5  Influence of PH Value on Quality of Steamed Bread in Table 5

| No. of water | PH value | Specific volume | Score | Aspect ratio | Score | Color | 10 | Surface structure | 10 | Internal structure | 15 | Softness | 10 | Elasticity | 10 | Chewy performance | 15 | Odor | 5 | Total score | 100 |
|--------------|----------|-----------------|-------|--------------|-------|-------|----|--------------------|----|-------------------|----|------------|----|-------------|----|------------------|----|------|----|------------|-----|
| 1            | 5        | 2.4             | 16    | 0.59         | 3     | 8     | 7  | 14                 |    | 8                 | 9  | 14                |    | 4          | 83 |
| 2            | 6        | 2.5             | 17    | 0.63         | 4     | 8     | 8  | 15                 |    | 9                 | 9  | 15                |    | 5          | 90 |
| 3            | 7        | 2.1             | 13    | 0.54         | 2     | 7     | 8  | 15                 |    | 7                 | 8  | 15                |    | 5          | 80 |
| 4            | 8        | 1.8             | 10    | 0.53         | 2     | 5     | 6  | 13                 |    | 6                 | 7  | 13                |    | 3          | 65 |
| 5            | 9        | 1.6             | 10    | 0.50         | 2     | 4     | 5  | 13                 |    | 5                 | 6  | 12                |    | 3          | 60 |

Table 6  Factor- level Table of Orthogonal Experiment

| Factors | Level | pH (A) | Level of water addition (ml/100g) (B) | Hardness(mg/L) (C) |
|---------|-------|--------|--------------------------------------|-------------------|
|         | 1     | 5      | 44                                   | 50                |
|         | 2     | 6      | 45                                   | 100               |
|         | 3     | 7      | 46                                   | 150               |

Table 7  Sensory Scoring and Analysis on The Measuring Result of Orthogonal Experiment to Steamed Bread

| No. | Specific volume | Score | Aspect ratio | Score | Color | 10 | Surface structure | 10 | Internal structure | 15 | Softness | 10 | Elasticity | 10 | Chewy performance | 15 | Odor | 5 | Total score | 100 |
|-----|-----------------|-------|--------------|-------|-------|----|--------------------|----|-------------------|----|------------|----|-------------|----|------------------|----|------|----|------------|-----|
| 1   | 2.68            | 18    | 0.60         | 3     | 7     | 8  | 13                 | 8  | 9                 | 14 | 4          | 84 |
| 2   | 2.74            | 19    | 0.66         | 5     | 9     | 9  | 14                 | 10 | 9                 | 15 | 5          | 95 |
| 3   | 2.63            | 1     | 0.60         | 3     | 8     | 8  | 12                 | 9  | 8                 | 15 | 5          | 86 |
| 4   | 2.62            | 18    | 0.58         | 3     | 9     | 9  | 15                 | 8  | 10                | 15 | 5          | 92 |
| 5   | 2.70            | 19    | 0.62         | 4     | 8     | 8  | 14                 | 8  | 8                 | 13 | 5          | 87 |
| 6   | 2.66            | 18    | 0.63         | 4     | 8     | 8  | 13                 | 7  | 7                 | 14 | 4          | 83 |
| 7   | 2.60            | 17    | 0.62         | 4     | 7     | 7  | 12                 | 6  | 6                 | 14 | 4          | 77 |
| 8   | 2.64            | 17    | 0.59         | 3     | 6     | 6  | 11                 | 5  | 8                 | 13 | 3          | 72 |
| 9   | 2.56            | 16    | 0.57         | 3     | 6     | 7  | 11                 | 5  | 7                 | 12 | 3          | 70 |

Table 8  Analysis on The Experimental Results for Total Score of Sensory Evaluation of Steamed Bread, Specific Volume, Color, Surface Structure and Softness

| Project | Sensory evaluation | Specific volume | Color | Surface structure | Softness |
|---------|-------------------|-----------------|-------|--------------------|----------|
|         | A     | B     | C      | A     | B     | C      | A     | B     | C    | A     | B     | C     | A     | B     | C    |
| K1      | 88    | 84    | 80     | 2.68  | 2.63  | 2.66  | 8.0   | 7.8   | 7.0  | 8.2   | 8.0   | 7.3   | 9.0   | 7.3   | 6.7  |
| K2      | 87    | 85    | 86     | 2.66  | 2.69  | 2.64  | 8.3   | 7.7   | 8.0  | 8.3   | 7.7   | 8.3   | 7.7   | 7.7   | 7.9  |
| K3      | 73    | 80    | 83     | 2.60  | 2.62  | 2.62  | 6.3   | 7.3   | 7.7  | 6.7   | 7.7   | 7.7   | 5.3   | 7.0   | 7.0  |
| Range   | 15    | 5     | 6      | 0.08  | 0.07  | 0.04  | 2.0   | 0.5   | 1.0  | 1.6   | 0.3   | 1.0   | 3.7   | 0.7   | 1.2  |