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Effects of Mashed Potatoes on Dough Properties and Quality of Steamed Bread

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Abstract: *Effect of mashed potato on the rheological properties of dough and optimization of mashed potato on fermentation technology were investigated. The results showed that the dough with 20% mashed potato had the best flour properties and tensile properties possessing 1.6 min travel time of dough, 2.2 min stability time of dough, 207 FU weakening degree, 41.7% water absorption rate, and 23 flour quality index was. The optimum dough parameters determined by single factor experiment and specific volume were 20% mashed potatoes addition, 50 min fermentation time and 32 ^{o}C. The effects of mashed potato on fermentation technology including sensory evaluation, specific volume, color difference and glue stickiness of steamed bread were discussed by quadratic orthogonal rotary combination design with the three factors and five levels. Response surface analysis (RSA) was used to analyze the data of these experiments. The optimum range of fermentation parameters were obtained, the addition of mashed potatoes was 20%-22%; the fermentation time was 38 min-50 min; and the fermentation temperature was 29-32 ^{o}C. The optimum fermentation parameters were obtained by validation experiments, the addition of mashed potato was 20%, the fermentation time was 50 min, and the fermentation temperature was 32 ^{o}C. Under these conditions, the specific volume was 2.35 ml/g, the sensory evaluation was 77, the whiteness was 75.7, and the stickiness was 9.53 J.*

Keywords: *Steamed bread, Dough rheological properties, Tensile properties, Fermentation parameters*

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I. Introduction

Potato, an annual herbal crop of Solanaceae, is food and vegetable crops, which has high nutritional value and medicinal value[1]. There are many nutrients in fresh potatoes with 9-20% starch content, 1.5-2.3% protein content, 0.1-1.1% fat content, 0.6-0.8% crude fiber content[2]. Nutritional components of potatoes per 100 g includes 66-113 J calorie, 11-60 mg calcium, 15-68 mg phosphorus, 0.4-4.8 mg iron, 0.03-0.07 mg thiamine, 0.03-0.11 mg riboflavin, 0.4-1.1 mg nicotinic acid[3]. Besides, carotene and ascorbic acid, an important ingredient to human body, are are rich in them. From the nutritional point of view, potatoes can provide a lot of energy to the human body, which is not provided by rice and flour.

Steamed bread is a kind of pasta with Chinese traditional characteristics. It is made by fermentation of flour and steaming[4]. There are many kinds of steamed bread, such as miscellaneous grain steamed bread, truffle and brown sugar steamed bread. As one of the main foods in our daily life, steamed bread made from wheat flour plays an indispensable role in China[5]. Accompanying the more attention of healthy diet and the attraction of coarse food grain, there is the prosperous of potato steamed bread with whole flour. Steamed mashed-potato bread has a unique advantage that cannot be achieved by potato whole flour steamed bread[6, 7]. It has higher safety, similar taste with white steamed bread, the fragrance of potatoes and costs relatively low. In this study, mashed potatoes were used as raw materials, and the orthogonal method was used to optimize the transportation of steamed mashed-potato bread. This research breaks through the traditional food production methods in the production technology and affords theoretical basis on the application of fresh potatoes. Mashed potatoes were used to make steamed bread, which enriched the types of steamed bread, provided a favorable means for the industrial production of new staple foods, and made it possible to increase economic benefits.

In this study, the main factors (the addition amount of mashed potato, fermentation time, fermentation temperature) in the fermentation process of steamed mashed-potato bread were tested by single factor test. The specific volume, color difference, glue and sensory evaluation of steamed mashed-potato bread were used as the evaluation indexes to study the better technology of steamed mashed-potato bread. On this basis, three factors, five levels and two times were carried out on steamed mashed-potato bread. The fermentation process of

steamed mashed-potato bread was optimized by using SAS software. The texture characteristics (glue stickiness) and sensory evaluation of steamed bread were taken as the evaluation indexes to further determine the appropriate technological conditions and form a relatively stable production process.

II. Test Materials And Methods

2.1 Experimental materials

Fresh potatoes (market purchase), flour (Zibo Yunhai Flour Factory), high activity dry yeast (Angel Yeast Co., Ltd.).

2.2 Dough preparation

Quantitative flour placed in a kneading bowl and mixed with water was kneaded at a constant temperature. According to the power consumption in the kneading process, the instrument automatically draws a characteristic curve, i.e. the powder curve, which reflected the variation of the comprehensive resistance of the mixing knife during the kneading process following the mixing time[8]. This curve was used to analyze the characteristics of dough formation. According to the test record curve, the following quality characteristics could be obtained, water absorption, formation time, stability time and weakening degree.

2.3 Tensile properties of dough

Water, flour and salt was used to make dough in the Farinograph under the specified conditions, kneaded the experimental dough in the kneader, and processed it into the prescribed shape in the moulder. After stretching the experimental dough and recording the required force, the curve obtained reflected the deformation characteristics of the dough[9].

According to the test record curve, the quality characteristics including extensibility of dough, tensile resistance at 50mm, maximum tensile resistance and area were obtained.

2.4 Processing technology of steamed mashed-potato bread

Mixture of mashed potatoe, flour, yeast and water was blended to prepare the dough, the dough was poured into the rolling mill to mold it, and then fermented at room temperature[10]. The fermented dough was placed at room temperature for 30 minutes to make it shape. Then the dough was put into the wake-up box for wake-up, and steamed in a multi-functional electric heater. Finally, the steamed steamed bread was taken out and cooled.

2.5 Determination of specific volume of steamed bread

The volume was determined by millet replacement method: fill the beaker with millet, took out some millet and poured it into the measuring cylinder[11]. The volume of the millet was slightly larger than the bread, put the bread into the beaker, and fill the beaker with millet in the measuring cylinder. Finally, the volume of the remaining millet in the measuring cylinder was the volume of the bread.

2.6 Color difference measurement

The steamed bread was peeled, two pieces in each group. Cut three 2 cm thick steamed bread slices to measure the color difference[12].

2.7 Texture determination

The method described by Zhang Xinwen was used to determine the texture of steamed bread[4, 13].

2.8 Determination of the level of test factors

The addition of mashed potato, fermentation time and fermentation temperature of steamed bread were taken as test factors, and the color difference, specific volume, glue stickiness and sensory evaluation of steamed mashed-potato bread were taken as test indexes. The 20% mashed potatoes addition, 50 min fermentation time and 32 ^{o}C fermentation temperature are zero level.

III. Result

3.1 Arrangement and results of the experiment

Three factors and five levels of quadratic rotation orthogonal method were used to test the color difference of steamed mashed potato bread by combining all factors. SAS9.1 software was used to analyze the data to explore the effect of fermentation technology on the quality of steamed mashed-potato bread. The data and arrangement of fermentation experiments are shown in Table 1.

Table 1 Test arrangement and result

No.	X1	X2	X3	Y1	Y2	Y3	Y4
1	1	1	1	2.18	76	67.7	9.83
2	1	1	-1	2.01	75	68.3	10.01
3	1	-1	1	1.97	75	73.1	9.95
4	1	-1	-1	2.40	79	71.0	10.56
5	-1	1	1	2.38	77	69.5	10.73
6	-1	1	-1	1.87	80	71.0	10.30
7	-1	-1	1	2.13	73	72.0	10.90
8	-1	-1	-1	2.32	80	70.3	9.98
9	1.68	0	0	2.09	73	70.0	10.28
10	-1.68	0	0	2.19	74	70.2	10.48
11	0	1.68	0	2.04	74	66.9	10.11
12	0	-1.68	0	2.03	73	71.1	10.38
13	0	0	1.68	1.95	73	72.0	11.35
14	0	0	-1.68	1.96	72	71.6	11.29
15	0	0	0	2.35	87	75.7	10.30
16	0	0	0	2.37	83	73.0	9.36
17	0	0	0	2.17	82	76.3	9.87
18	0	0	0	2.33	86	73.0	9.34
19	0	0	0	2.43	86	71.6	9.30
20	0	0	0	2.43	88	75.8	9.38
21	0	0	0	2.38	85	73.4	9.40
22	0	0	0	2.29	86	71.6	9.21
23	0	0	0	2.43	85	74.4	9.13

Note: X1, the amount of mashed potatoes (%); X2, the time of fermentation (min); X3, the temperature of fermentation (^{o}C); Y1, the specific volume of mashed potatoes; Y2, the sensory organ of mashed potatoes; Y3, the whiteness of mashed potatoes; Y4, the stickiness of mashed potatoes.

3.1 Sensory Response Surface Analysis and Results of Steamed mashed-potato bread

The sensory evaluation of steamed mashed-potato bread fermentation was processed, and the variance analysis of regression model was obtained (Table2).

Table 2 Variance analysis of regression model for sensory evaluation of steamed mashed-potato bread

Source of variation		Freedom	Sum of squares	Mean square	F-value	P-value
Regression	Linear	3	13.1879	0.0195	0.55	0.6593
	The two item	3	537.7403	0.7932	22.28	<0.0001
	Interaction item	3	22.3750	0.0330	0.93	0.4554
	Total regression	9	573.3033	0.8457	7.92	0.0005
Residual	Loss of imitation	5	76.6097	15.3219	4.38	0.0323
	Random error	8	28.0000	3.5000		
	Total residual error	13	104.6097	8.0469		
	The sum	22				

The regression model of sensory evaluation of steamed mashed-potato bread had the determinant coefficient of R^2=0.8457. The second term (Pr=<0.01), the total regression (Pr=0.0005<0.01) and the mismatch (Pr=0.0323<0.05) were significant. The sensory evaluation data of steamed mashed-potato bread fitted with the model.

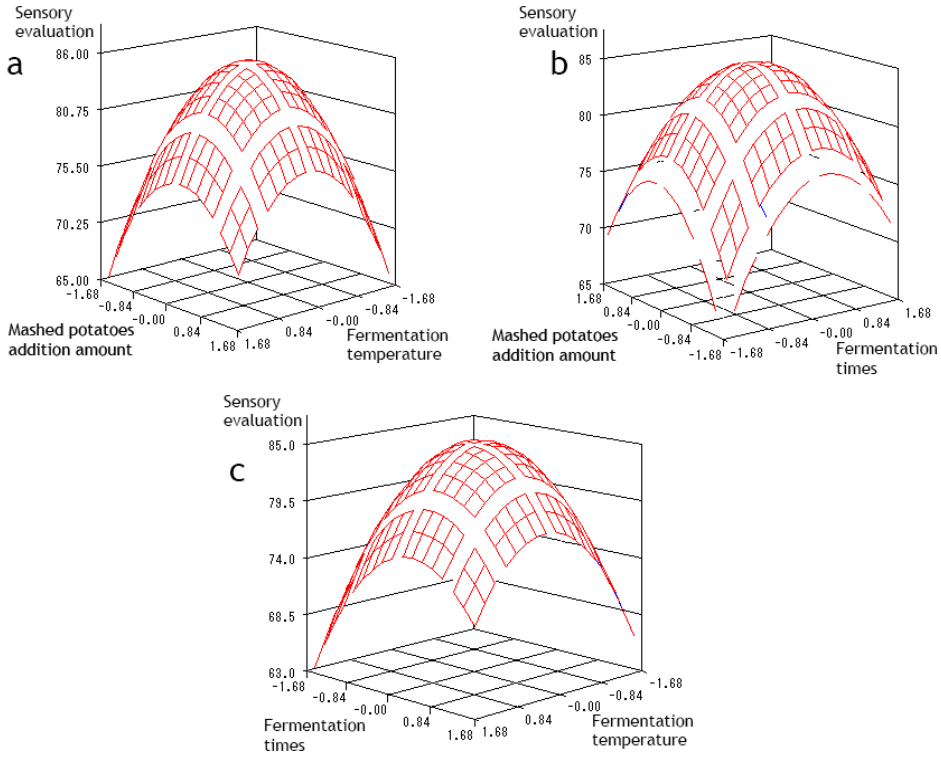

Fig. 1 Sensory evaluation response surface analysis of steamed mashed-potato bread

The sensory evaluation scores of steamed mashed-potato bread increased first and then decreased with the increase of mashed potatoes. The taste of steamed bread improved first and then deteriorated with the increase of fermentation temperature with the fixed amount of mashed potatoes (Fig. 1a)[14]. The steamed bread tasted better at the beginning, and become worse with the increase of mashed potatoes, same trend of taste observed following the increase of fermentation time (Fig. 1b). The increase of fermentation time and temperature lead to the deterioration. During the fermentation process, excessive fermentation time and high fermentation temperature induced the excessive ferment and affected the taste of steamed bread. (Fig. 1c).

3.2 Response Surface Analysis of Specific Volume of Potato Mud Steamed Bread

The results of specific volume of steamed mashed-potato bread were processed, and the variance analysis of regression model (Table 3) and response surface were obtained.

Table 3 Variance Analysis of Specific Volume Regression Model for Steamed mashed-potato bread

Source of variation		Freedom	Sum of squares	Mean square	F-value	P-value
Regression	Linear	3	0.0167	0.0225	0.58	0.6359
	The two item	3	0.3503	0.4704	12.21	0.0004
	Interaction item	3	0.2533	0.3402	8.83	0.0019
	Total regression	9	0.6204	0.8331	7.21	0.0009
Residual	Loss of imitation random error	58	0.0568	0.0071	1.90	0.1999
	Total residual error	13	0.1242	0.0095		
	The sum	22				

The regression model of potato mud steamed bread volume was $R^2 = 0.8331$, the second term ($Pr = 0.0004 < 0.01$), the interaction phase ($Pr = 0.0019 < 0.01$) and the total regression ($Pr = 0.0009 < 0.01$) were significant, otherwise, the other items were not significant.

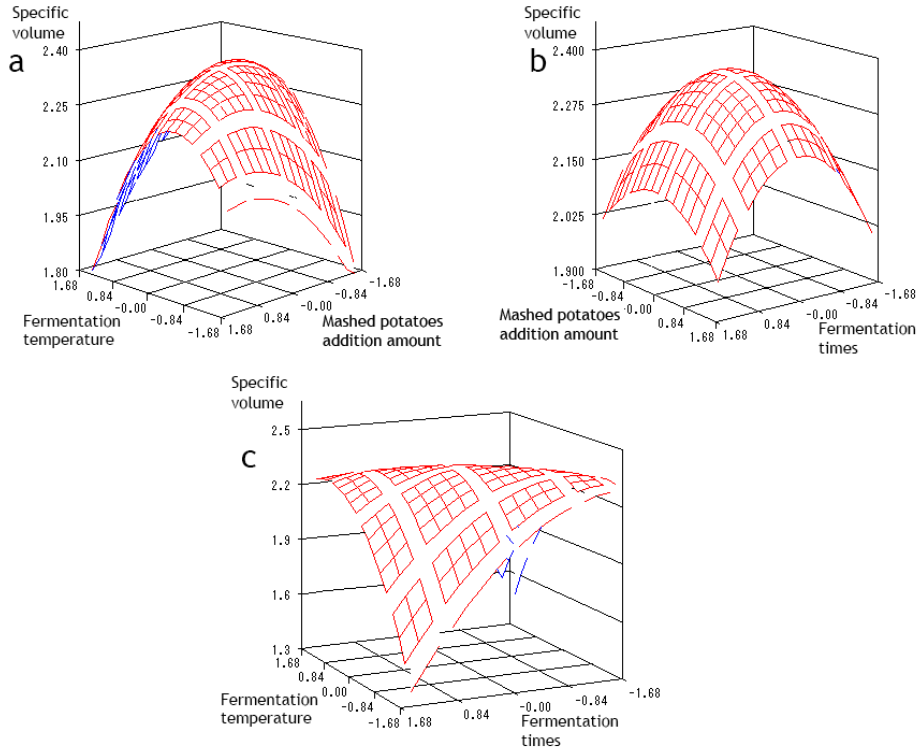

Fig. 2 Response Surface Analysis of the Effect of Fermentation Parameters on the Specific Volume of Potato Mud Steamed bread

Following the increase of fermentation temperature and the addition of mashed potatoes, the specific volume had the maximum value (Fig. 2a). The same trend appeared in the process of the increasing addition of mashed potatoes addition and fermentation time (Fig. 2b). However, the increase of fermentation time leads the increase of specific volume of steamed bread (Fig. 2c).

3.3 Whiteness of steamed mashed-potato bread

The whiteness of steamed mashed-potato bread were processed, the variance analysis of regression model and response surface were obtained (Table 4 and Figure 3).

Table 4 Variance analysis of regression model for whiteness of steamed mashed-potato bread

Source of variation		Freedom	Sum of squares	Mean square	F-value	P-value
Regression	Linear	3	22.1585	0.1659	3.71	0.0397
	The two item	3	76.0118	0.5691	12.73	0.0004
	Interaction item	3	9.5237	0.0713	1.59	0.2385
	Total regression	9	107.6942	0.8063	6.01	0.0020
Residual	Loss of imitation	5	0.5788	0.1157	0.04	0.9990
	Random error	8	25.3000	3.1625		
	Total residual error	13	25.8788	1.9906		
	The sum	22				

The determinant coefficient of regression model for whiteness of steamed mashed-potato bread was R^2=0.8063. The second term (Pr<0.005) and total regression (Pr<0.005) were significant, and the other items were not significant. The data of whiteness of steamed mashed-potato bread was fitted with the model.

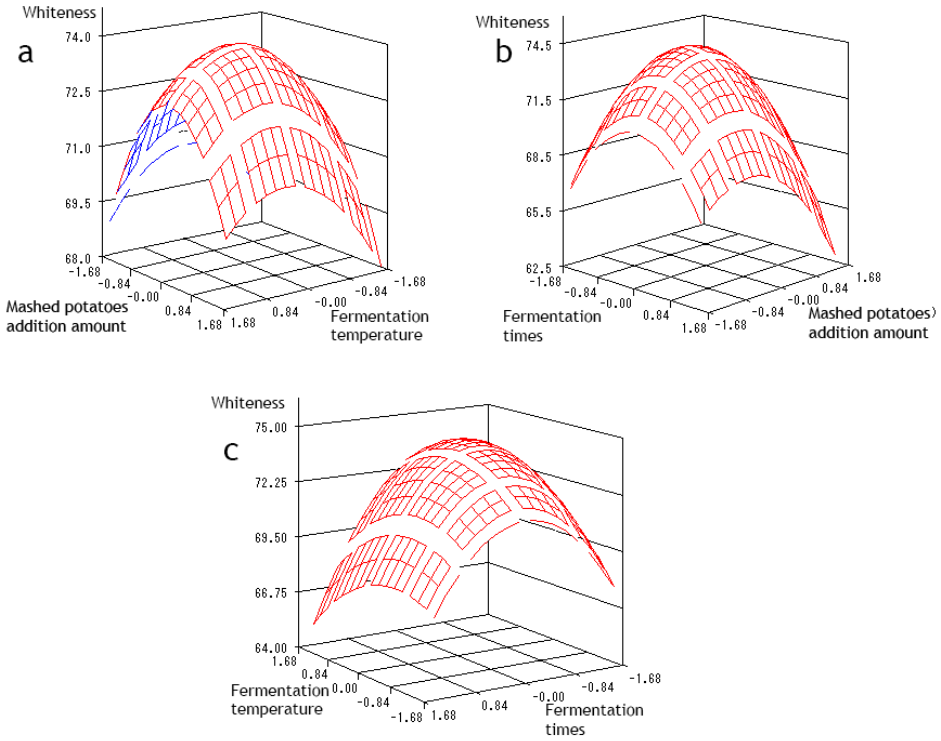

Fig. 3 The corresponding surface of fermentation parameters on the addition of mashed potatoes

The whiteness of steamed mashed-potato bread had the maximum value following the variation of mashed potato addition amount and fermentation temperature (Fig. 3a)[15]. The same trend appeared in the process of the increasing addition of mashed potatoes addition and fermentation time (Fig. 3b). The whiteness of steamed mashed-potato bread increased first and then decreased with the increase of fermentation time (Fig. 3c).

3.4 Response surface analysis of stickiness of steamed mashed-potato bread

The results of stickiness of steamed mashed-potato bread were processed, and the variance analysis of regression modeland response surface was obtained (Table 5 and Fig. 4).

Table 5 Analysis of variance of regression model for stickiness of steamed mashed-potato bread

Source of variation		Freedom	Sum of squares	Mean square	F- value	P-value
Regression	Linear	3	0.3649	0.0396	0.83	0.4985
	The two item	3	6.2910	0.6832	14.39	0.0002
	Interaction item	3	0.6569	0.0713	1.50	0.2604
	Total regression	9	7.3128	0.7942	5.57	0.0029
Residual	Loss of imitation	5	0.7921	0.1584	1.15	0.4090
	Random error	8	1.1026	0.1378		
	Total residual error	13	1.8947	0.1457		
	The sum	22				

The regression model of the stickiness of steamed mashed-potato bread was R^2=0.7942. The second term (Pr<0.01) and the total regression (Pr<0.01) were very significant, and the other items were not significant. The results show that the model of whiteness of steamed mashed-potato bread was consistent with the data.

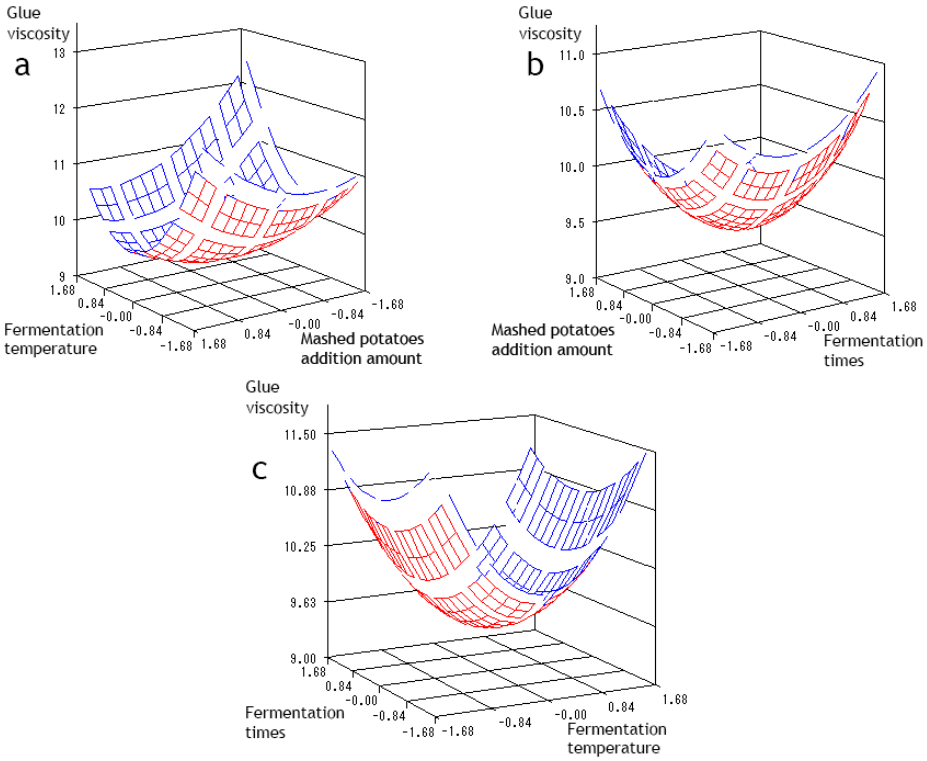

Fig. 4 Surface analysis of stickiness of steamed mashed-potato bread

The viscosity first decreased and then increased with the increase of fermentation temperature at 50 min fermentation time (Fig. 4a)[16]. The addition of mashed potatoes increased, and the viscosity maintained the minimum value with the fermentation temperature was 32 ^{o}C (Fig. 4b). The stickiness of steamed mashed-potato bread decreased first and then increased following the increase of fermentation time (Fig. 4c).

IV. Conclusion

The specific volume of steamed mashed-potato bread was taken as an index, the optimum parameters were as follows: the addition of mashed potato was 20-22%[17], the fermentation time was 38 min-50 min, and the fermentation temperature was 29-32%. The sensory evaluation of steamed mashed-potato bread was taken as a reference index, the optimum parameters were as follows: addition amount of mashed potato was 16%-20%, fermentation time was 50 min-54 min, and fermentation temperature was 29-32 ^{o}C. The whiteness of steamed mashed-potato bread was taken as an index, the optimum parameters were as follows: the addition of mashed potatoes was 20-21%, the fermentation time was 41 min-50 min, and the fermentation temperature was 31-36 ^{o}C. The stickiness of steamed mashed-potato bread was taken as an index, the optimum parameters were as follows: the addition of mashed potatoes was 20%-24%, the fermentation time was 50 min-61 min, and the fermentation temperature was 32 -33 ^{o}C.

The sensory evaluation and specific volume of steamed mashed-potato bread were taken as the main reference indexes in this experiment. The optimum fermentation parameters were obtained by synthesizing other indexes, the addition of mashed potatoes was 20%-24%, the fermentation time was 50 min-60 min, and the fermentation temperature was 32-33.

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