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Study on Technology of Shrimp Sauce Pickles

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Abstract: The pickle process optimization of rutabaga is studied in this paper. Based on single factor experiment, ratio of soy sauce and shrimp oil, amount of brown sugar added, $CaCl_2$ adding amount were selected to conduct 3 factors, 3 levels central combination experiment according to principle of Box-Behnken experiment. Results showed that: technological factors that influenced the quality of shrimp sauce pickles according to the primary and secondary order was volume ratio of soy sauce and shrimp oil, amount of brown sugar added, $CaCl_2$ adding amount; the optimum processing technologies was that rutabaga 100 g, soy sauce and shrimp oil ratio of 3.318, brown sugar concentration 2.87 % and $CaCl_2$ concentration 0.04 %. The comprehensive score of shrimp sauce pickles under the condition of optimum process was 91.80 points, compared to the theoretical prediction value of 91.90. These revealed that the regression equation optimized by response surface analysis had practical guiding significance.

Keywords: Shrimp sauce pickles, pickle technology, response surface analysis

1 Introduction

Shrimp oil is rich in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are necessary for human beings. They can prevent cardiovascular and cerebrovascular diseases, inflammatory reaction diseases, malignant tumors, dementia, diabetes mellitus and visual impairment and so on [1]. Studies have shown that mustard head, as a kind of pickled vegetables, contains a lot of biogenic amines, which is of great significance to improve human health [2].

The production of pickled vegetables in China has a history of more than 200 years. As a popular accompaniment food, pickled vegetables not only sell well at home, but also abroad [3]. With the continuous improvement of living standards, people are increasingly demanding the quality of pickles [4]. Most of the traditional pickles in China are manufactured by hand, which has some shortcomings, such as backward production equipment, high labor intensity of producers, low output of products, easy pollution of production environment and slow pickling process [5]. In addition, at present, there are many food safety problems in pickle industry, such as excessive nitrite content, excessive addition of preservatives and excessive additives, which seriously deviate from the growing human consumption demand [6-8]. Therefore, while guaranteeing the quality of pickled vegetables, it is of great significance to produce pickled vegetables with excellent fragrance and satisfying the needs of mass consumption [9-11]. In recent years, more and more people reduce the unsafe factors of pickled vegetables by low salinization production technology and inoculation and fermentation [12-13].

In order to meet the improvement of the consumption level of market economy and the needs of consumers, it is particularly important to improve the pickling speed of pickled vegetables. In this experiment, shrimp sauce pickles as experimental material, on the basis of single factor experiment, using the response surface method of shrimp oil pickling parameters pickles were optimized, in order to improve the quality and speed of oil pickled pickles.

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2 Materials and methods

2.1 Materials

Sugar, calcium chloride, shrimp oil (East Ancient Fresh) and other accessories are all of the best quality in the market and meet the food standards; water must meet the national health standards for drinking water; mustard head: fresh and full, insect-free, moderate maturity of the head vegetables after a high concentration of salt salted semi-finished products.

2.2 The Main Reagents

Potassium chromate, sodium hydroxide, silver nitrate, all of which are food grade or analytical purity; phenolphthalein (indicator).

2.3 Instrument and Equipment

UV-8000 ultraviolet-visible spectrophotometer, acid burette, basic burette, electronic balance, titration rack, kitchen knife, chopping board, vacuum packaging machine, pickle jar or pickle jar, food packaging bag, etc.

2.4 Processing process

Material select → Cut the mustard → Mix → Pickle → Bag → Vacuum sealing → Check up → Sterilize → Cool down → Insulation and inspection → Boxed up

2.5 Processing Method

Cut the mustard head into dices (it tastes better than silk by sensory evaluation). Choose brown sugar, calcium chloride, shrimp sauce and soy sauce to add to the raw material in a certain proportion, and marinate at room temperature for different marinating time.

2.6 Design and Optimization of Experimental Factors

2.6.1 Optimizing pickling process by single factor test

2.6.1.1 Effect of volume ratio of soy sauce to shrimp oil on quality of mustard

Five treatment groups were set up in this experiment. Each treatment group was accurately weighed 100 g mustard and put into 1000 ml beaker. Under the same experimental conditions, the volume ratios of soy sauce to shrimp oil were 1:1, 2:1, 3:1, 4:1, 5:1, 3% brown sugar, 0.1% $CaCl_2$ and 14 hours of pickling, and then the sensory evaluation was carried out.

2.6.1.2 Effect of brown sugar content on the quality of mustard cucumber

Five control groups were set up in this experiment. Each treatment group was accurately weighed 100 g mustard and put into 1000 ml beaker. Under the same experimental conditions, the amount of brown sugar added by mass fraction was 1%, 2%, 3%, 4%, 5%, the volume ratio of soy sauce to shrimp oil was 3:1, the amount of $CaCl_2$ added was 0.1%, and cured for 14 hours. Finally, the samples were extracted and dried, and sensory evaluation was carried out for each group

2.6.1.3 Effect of $CaCl_2$ Addition on the quality of mustard dice

The test set of 5 control group, each treatment group accurately weighed mustard pieces 100 g, 1000 ml were placed in a beaker. In the same experimental conditions, the amount of $CaCl_2$ added by mass fraction were 0%, 0.05%, 0.1%, 0.15%, 0.2%, soy sauce and oil volume ratio of 3:1, adding amount of brown sugar 3%, salted 14 h. Finally, it was extracted and dried, and its sensory evaluation was carried out.

2.6.2 Design of response interview experiments

Considering the influence of various factors on the quality of the mustard block, on the basis of single factor test, according to the central composite design principle Box-Behnken. Taking the comprehensive

quality score of mustard as the optimization index, the ratio of soy sauce to shrimp oil, the amount of brown sugar and $CaCl_2$ were selected to optimize the design. Table 1 shows the design of each factor level.

Table 1. Factors and Levels in the response surface design

		Level		
Factor	Code	-1	0	1
soy sauce: shrimp oil	A	2:1	3:1	4:1
The amount of brown sugar	B	2%	3%	4%
Adding amount of $CaCl_2$	C	0.05%	0.1%	0.15%

2.6.3 Product evaluation method

Ten food professionals with experience in sensory evaluation were asked to evaluate the quality of products according to the following sensory evaluation criteria. The final score of sensory evaluation was taken as the average score of 10 people. The sensory evaluation criteria are shown in Table 2.

Table 2. Sensory scoring criteria of shrimp sauce pickles

Color	Taste	Texture	Total points
Reddish brown 15～20	Medium taste, moderate saltiness and sweetness 45～50	Moderate brittleness, mustard chunks of meat rich, tenacity 25～30	85～100
Lighter color 10～15	Taste light, slightly sweet, moderate salinity 40～45	Medium brittleness, slightly poorer fleshy fullness of mustard pieces, slightly poorer toughness 20～25	75～85
Dark red brown 5～10	Taste light, small sweetness, salty taste slightly heavy 35～40	Poor crispness; slightly soft flesh of mustard cubes 15～20	35～70

Note: The number of people who had sensory evaluation at each time remains unchanged

2.6.4 Data processing and analysis

Using Design Expert 8.0.6 software [14], multiple linear regression analysis was carried out on the response test results, and the second-order polynomial equation was fitted to study the effects of volume ratio of soy sauce to shrimp oil, brown sugar content and $CaCl_2$ content on the quality of mustard cubes. The coefficients of the regression equation obtained were compared significantly, and the effects of experimental factors and levels on the response values were further analyzed.

3 Results and discussion

3.1 Optimizing Pickling Process by Single Factor Test

3.1.1 Effect of volume ratio of soy sauce to shrimp oil on sensory score

As can be seen from Figure 1, the volume ratio of soy sauce to shrimp oil has a certain effect on the quality of mustard cubes. When the volume ratio of soy sauce to shrimp oil was 5:1, the sensory score of mustard was the highest. With the increase of soy sauce, the sensory score decreased gradually. This is because with the increase of the amount of soy sauce, the taste of shrimp oil is gradually covered, the sweet taste becomes smaller, the salty taste is too heavy, which affects the quality of mustard pieces. When the amount of soy sauce is small, it leads to insufficient pickling liquid, inadequate pickling of mustard pieces, too heavy taste, poor taste, too light color, visual effect is also significantly worse.

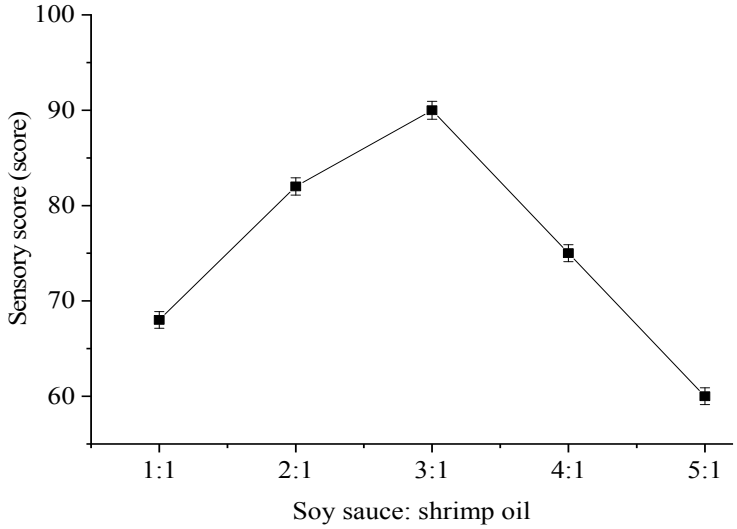

Figure 1. Effect of the ratio of soy sauce and shrimp sauce addition on the sensory score

3.1.2 The effect of brown sugar content on sensory score

As can be seen from Figure 2, the amount of brown sugar can also affect the quality of mustard cubes. With the increasing amount of brown sugar, the sensory score of mustard slices increased slowly at first, then decreased. When the amount of brown sugar was 3%, the sensory score of mustard slices was the highest. When the amount of brown sugar is small, it is not enough to neutralize the taste and fragrance of soy sauce and shrimp oil, and the color is light, which makes the quality of mustard pieces worse. When the amount of brown sugar is large, it also conceals the taste and fragrance of soy sauce and shrimp oil, and the color becomes too heavy, which will also lead to the quality decline of mustard pieces.

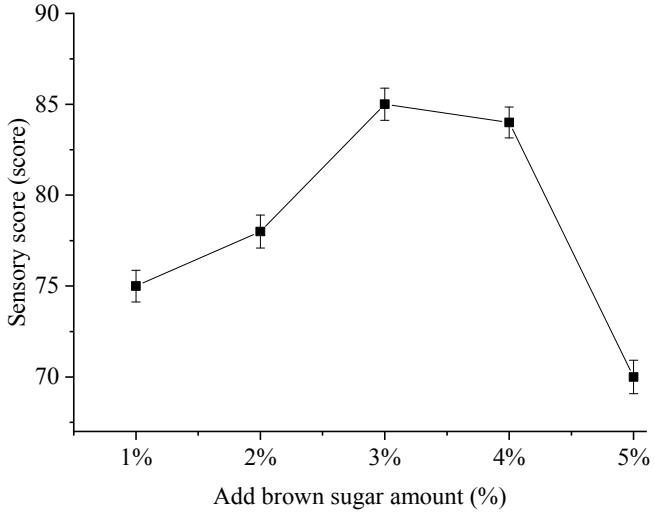

Figure 2. Effect of brown sugar addition on the sensory score

3.1.3 Effect of CaCl2 addition on sensory score

As can be seen from Figure 3, the addition of $CaCl_2$ also affects the quality of mustard cubes. It was found that adding $CaCl_2$ directly into pickles could achieve good crispness-preserving effect [18], but not the greater the amount of $CaCl_2$ added, the better the crispness-preserving effect. Controlling the amount

of $CaCl_2$ added to pickles at 0.1% could achieve good crispness-preserving effect [19], and the sensory score was the highest at this time.

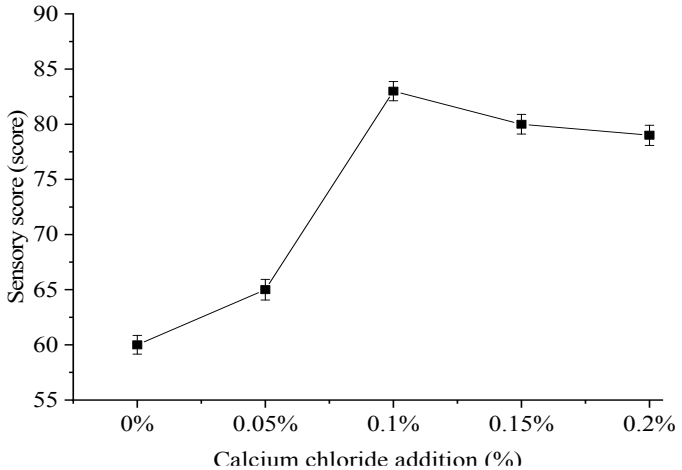

Figure 3. Effect of calcium chloride addition on the sensory score

3.2 Response Surface Method Optimized Test and Result Analysis

3.2.1 Establishment of regression equation

Table 3. Protocol and experiment results of response surface design

Test number	Soy sauce: Shrimp oil(A)	Brown sugar content /%(B)	The amount of $CaCl_2$ added /%(C)	Sensory score / points(Y)
1	1	1	0	77.3
2	-1	0	-1	74.2
3	1	-1	0	82.5
4	-1	1	0	70.4
5	-1	-1	0	73.8
6	0	0	0	92.2
7	1	0	1	77.8
8	0	1	-1	70.5
9	0	-1	-1	78.1
10	0	1	1	70.5
11	1	0	-1	80.7
12	0	0	0	90.4
13	0	-1	1	70.6
14	0	0	0	91.8
15	0	0	0	90
16	0	0	0	91
17	-1	0	1	70

On the basis of single factor test and according to Box-Behnken test design principle [20], three factors and three levels of response surface analysis were carried out for soy sauce: shrimp oil (A), brown sugar (B), $CaCl_2$ (C). The comprehensive quality score (Y) was taken as the measurement index. The design scheme and results of the experiment were shown in Table 1. Design-Expert 8.0 software was used for regression analysis of test data, and the regression equation was obtained as follows: $Y=91.08+3.86A-2.79B+0.050C-0.45AB+0.58\ AC-0.62BC-6.04A^2-9.04B^2-8.12C^2$. Table 3 shows that the response regression

model reaches a very significant level when the confidence interval is 0.01. The missing item P = 0.9373 > 0.05, and the difference is not significant when the confidence interval is 0.05. It shows that the equation fits the test well and the error is small. The linear relationship between each factor and the response value is obvious. This model can be used to analyze and predict the sensory score of shrimp sauce pickled vegetables.

The results of variance analysis of regression model showed that when the confidence interval was 0.01, the sensory scores of the first term A, B, C, BC and the second term $A^2B^2C^2$ shrimp sauce and pickle reached a very significant level. Analyzing the influence degree of each factor, the F value of each factor can directly reflect the importance of different factors to the test index. The larger the F value, the greater the impact on the test index [21]. From the table of variance analysis, the order of influence degree of each factor on sensory score of shrimp sauce pickled vegetables was soy sauce: shrimp oil (A) > brown sugar (B) > $CaCl_2$ (C).

Table 4. Analysis results of regression and variance

Source of variance	Sum of squares	Freedom	mean square	F value	P value	Saliency
module	1165.12	9	129.46	242.27	<0.0001	Extremely significant
A	111.75	1	111.75	209.13	<0.0001	Extremely significant
B	33.21	1	33.21	62.15	0.0001	Extremely significant
C	26.64	1	26.64	49.86	0.0002	Extremely significant
AB	0.81	1	0.81	1.52	0.2580	
AC	0.42	1	0.42	0.79	0.4034	
BC	14.06	1	14.06	26.32	0.0014	Extremely significant
A^2	147.31	1	147.31	275.69	<0.0001	Extremely significant
B^2	353.67	1	353.67	661.87	<0.0001	Extremely significant
C^2	379.20	1	379.20	709.64	<0.0001	Extremely significant
Residual	3.74	7	0.53			
Missing item	0.33	3	0.11	0.13	0.9373	
Pure error	3.41	4	0.85			
The sum	1168.86	16				

Note: P < 0.01 is extremely significant, 0.01 < P < 0.05 is significant.

3.2.2 Response surface analysis

According to the above regression equation and variance analysis of regression model, a three-dimensional response surface map of shrimp sauce pickling process is drawn, as shown in Figure 4-6. The shape of response surface was tested and the effects of different factors on sensory evaluation of shrimp sauce pickled vegetables were analyzed.

The effect of the volume ratio of soy sauce to shrimp oil and the amount of red sugar on sensory score and the interaction between them when $CaCl_2$ is zero (Figure 4). When the ratio of soy sauce to shrimp sauce was unchanged, the sensory score of shrimp sauce pickled vegetables increased first and then decreased with the increase of brown sugar content; when the amount of brown sugar was unchanged, the sensory score increased first and then decreased with the increase of the ratio of soy sauce to shrimp sauce. In addition, compared with the amount of brown sugar added, the volume of soy sauce and shrimp oil has a greater impact on the sensory score of shrimp sauce pickled vegetables.

The effect of the volume ratio of soy sauce to shrimp oil and $CaCl_2$ addition on sensory score and the interaction between them when the brown sugar content is zero (Figure 5). When the volume ratio of soy sauce to shrimp sauce was unchanged, the sensory score of shrimp sauce pickled vegetables increased first and then decreased with the increase of $CaCl_2$ content; when the volume ratio of soy sauce to shrimp sauce was unchanged, the sensory score increased first and then decreased with the increase of the volume ratio of shrimp sauce to shrimp sauce. In addition, compared with the amount of brown sugar added, the volume ratio of soy sauce to shrimp oil has a greater influence on the sensory score of shrimp sauce pickled vegetables.

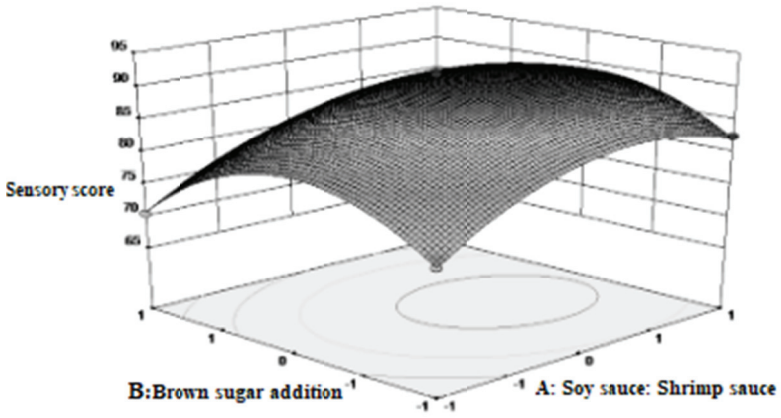

Figure4. Interactive effects of soy sauce and shrimp sauce addition and brown sugar addition

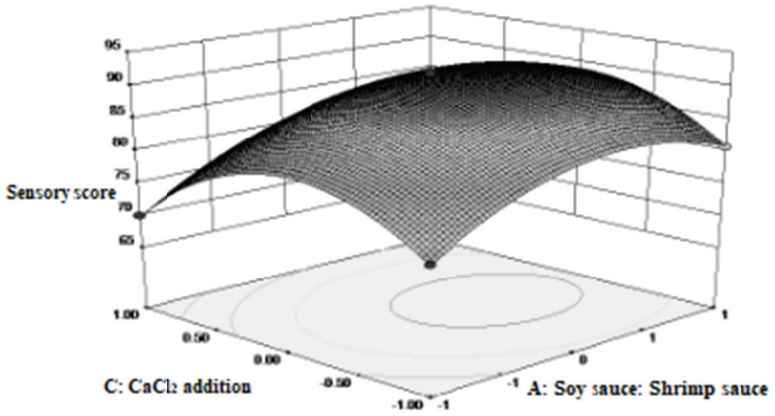

Figure 5. Interactive effects of soy sauce and shrimp sauce addition and calcium chloride addition

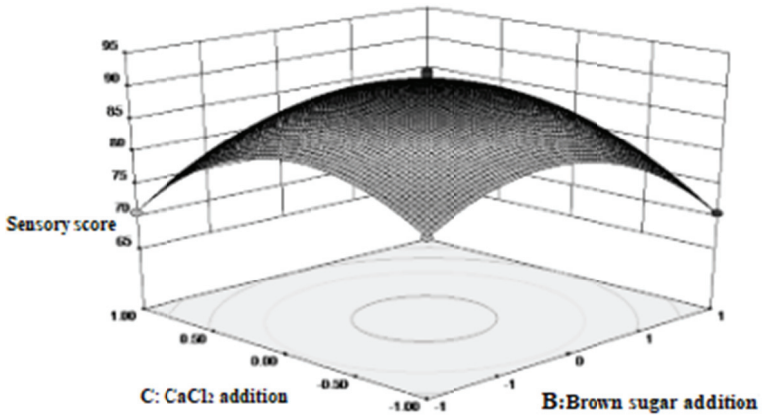

Figure 6. Interactive effects of brown sugar addition and calcium chloride addition

When the volume ratio of soy sauce to shrimp oil is zero, the amount of brown sugar and $CaCl_2$ additions have a significant impact on the sensory score (Figure 6). When the amount of brown sugar was unchanged, the sensory score of shrimp sauce pickled vegetables increased first and then decreased with the increase of $CaCl_2$ content; when the amount of $CaCl_2$ was unchanged, the sensory score increased first and then decreased with the increase of brown sugar content.

3.2.3 Verification test

According to the results of response surface analysis and the data processed by Design-Expert.8.0.6 software, we can get a set of recipes of shrimp sauce pickled vegetables with the highest sensory score: mustard cubes 100 g, volume ratio of soy sauce to shrimp sauce 3.318, brown sugar 2.87%, CaCl2 0.04%. Under these conditions, the sensory score of shrimp sauce pickled vegetables was 91.90. In order to verify the reliability of the model, the sensory scores of shrimp sauce pickled vegetables were 91.9, 91.0 and 91.5 respectively after repeated experiments under optimized conditions. Compared with the theoretical prediction value of 91.90, the average sensory score is 91.80, and the relative error is about 0.1%, which indicates that the regression model has good fit to the actual situation, which further validates the feasibility of the model. It is shown that the regression equation obtained by using response surface software optimization has practical guiding significance.

3.3 Determination of Physical and Chemical Indexes

As we can see from the table 5 that the salt content of mustard decreases greatly after pickling, considering that this should be due to the effect of dehydration; the total acid decreases slightly, indicating that pickling does not affect the total acid in pickled vegetables; the water content of shrimp sauce pickled vegetable increased to a certain extent, probably due to the addition of shrimp oil in the pickling process.

Table 5. The comparison of the physical and chemical indicators

Index	Shepherd's purse	Shrimp sauce and pickled vegetables
Salt content（%）	14.28	5.45
Total acid (g/100g in lactic acid)	0.96	0.91
Water content (%)	75.50	85.70

4 Conclusion

The shrimp sauce pickled vegetables obtained in this study are bright in color, lustrous, moderately salty, delicate in taste, uniform in texture, and have the unique delicious and fragrant flavor of shrimp oil without peculiar odor. Shrimp sauce pickled vegetable is a novel pickled vegetable product, which not only retains the unique flavor of shrimp oil, but also possesses the characteristics of shepherd's purse, and achieves the goal of full color, fragrance and high nutritional value.

According to Box-Behnken Design principle, through single-factor experiment, the volume ratio of soy sauce to shrimp oil, the amount of brown sugar and $CaCl_2$ were selected to carry out three-factor three-level central combination experiment. The optimum combination conditions were determined as follows: mustard cubes 100 g, soy sauce to shrimp sauce volume ratio 3.318, brown sugar content 2.87, $CaCl_2$ content 0.04 %. The average sensory score was 91.80. Compared with the theoretical predicted value 91.90, the relative error was about 0.1%. The validity of the mathematical model was verified, which indicated that it was feasible to optimize the technical parameters of shrimp sauce pickling process by response surface analysis.

Declaration of interest The authors declare no conflict of interest.

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