Optimization of Peanuts with Yingshan Yunwu Tea Flavor Using Response Surface Methodology

Nan LUO[1], Yuchao TIAN[1], Qingling ZHU[1], Haijian LIU[1], Zhiling HU[1], Furong LIU[1], Fan WANG[1], Ziyi ZHANG[1], Chang LIU[1,2]*

1. College of Biological and Agricultural Resources, Huanggang Normal University, Huanggang 438000, China; 2. Hubei Key Laboratory of Economic Forest Germplasm Improvement and Resources Comprehensive Utilization, Hubei Collaborative Innovation Center for the Characteristic Resources Exploitation of Dabie Mountains, Huanggang Normal University, Huanggang 438000, China

Abstract　Yingshan Yunwu tea was a characteristic agricultural product in Hubei Province. It possesses special flavor and great taste. However, the lack of Yunwu tea products made it lose competition in the market. In this study, the peanuts with Yingshan Yunwu tea flavor were cooked, and the effect of factors on the sensory test was investigated. The single-factor experiment was performed to study all factors on the sensory score of the peanut, including tea amount, salt amount, sugar amount, flavor amount and cooking time. Then, response surface methodology with the Box-Behnken design were carried out, and the optimal formulation composition was 100 g peanuts, 500 mL of water, 25 g tea, 5 g salt, 8 g sugar and 1 g tea flavor with a sensory score of 94. 3 points. This study demonstrated that the peanuts with Yingshan Yunwu flavor could be a valuable product for the market and contribute to promoting practical application of Yingshan Yunwu tea.

Key words　Tea products, Yingshan Yunwu tea, Peanuts, Formulation, Response surface methodology (RSM)

1　Introduction

In recent years, the global tea market demand has continued to grow. The natural and healthy characteristics of tea and the promotion of tea culture have made tea and tea products more and more acceptable[1]. Tea snacks can improve the nutritional value of food and give the product the flavor of tea. For example, instant tea have been shown to improve the aroma of meat products[2].

China is a major peanut producing country, with its annual output and export volume ranking top in the world. At present, it has become a hot spot in peanut food processing to develop peanut products which could meet consumer consumption needs. The processing technology of peanuts were mainly seasoning, wrapping and crushing[3-5]. The seasoning products were spicy, spiced, pepper and salt peanuts. The coating products are honey coating, strange taste peanut kernel, *etc.* The grinding products are peanut powder, peanut butter, peanut milk and so on. Yingshan Yunwu tea was characteristics of agricultural products in Hubei Province, which possess special flavor and great taste. However, the lack of Yunwu tea products made it lose competition in the market.

In this study, the peanuts with Yingshan Yunwu tea flavor were cooked, and the effects of factors on the sensory test were investigated. Based on the results, we put forward the recommendations for the optimal formulation of peanuts.

2　Materials and methods

2. 1　Materials　Yingshan Yunwu tea was provided by Dengcun Yingshan Tea Co., Ltd. (Hubei Province, China). Tea flavor was purchased from Qilu Biotechnology Co., Ltd. (Shandong, China). Salt, sugar and fresh peanut were obtained from local market.

2. 2　Preparation of peanut with Yingshan Yunwu flavor
We first weighed and washed 100 g peanuts in the pot, and added an amount of salt, sugar, tea and tea flavor. Then, put 500 mL of water in the pot and boiled for 50 min. Finally, we filtered and cooled the peanuts.

2. 3　Sensory test　A sensory test for the prepared peanut with Yingshan Yunwu tea flavor was performed by evaluating the sensory properties, including appearance, color, taste, and flavor. Ten trained panelists aged from 18 to 25 with both genders were chosen from students of food science and technology. The standard for effervescent tablet evaluation is shown in Table 1. Total score of each group was 100 points, consisting of appearance (1 - 20 points), color (1 - 20 points), taste (1 - 30 points) and flavor (1 - 30 points). The overall score of each tablet was calculated, and the average was taken as final score.

2. 4　Single-factor experiment　The single-factor experiment was performed to study all factors on the sensory score of the peanut, including tea amount, salt amount, sugar amount, flavor amount and cooking time. The ranges of tea amount, salt amount, sugar amount, flavor amount and cooking time were 15 - 35 g, 3 - 11 g, 6 - 14 g, 0. 6 - 1. 4 g, and 20 - 60 min, respectively.

2. 5　Optimization of experiment design with response surface method (RSM)　In order to optimize the formulation of

peanut with Yingshan Yunwu tea flavor, the RSM was used by conducting Box-Behnken Design (BBD). The amounts of tea amount, sugar amount and flavor amount are usually main factors affecting their sensory properties[6] Therefore, three factors with three levels in the BBD were the amounts of tea amount, sugar amount and flavor amount, as shown in Table 2. The response and data analysis of BBD were performed using the Design-Expert 13.0.

Table 1   Evaluation standard of peanuts with Yingshan Yunwu flavor

Indicator	Evaluation standard	Score // points
Appearance	Complete surface	15 – 20
	Slight damage on surface	8 – 14
	Severe damage on surface	1 – 7
Color	Even color	15 – 20
	Slightly uneven color	8 – 14
	Severe uneven color	1 – 7
Taste	Moderate sweet, no astringent	21 – 30
	More sweet, slight astringent	11 – 20
	Too sweet and astringent	0 – 10
Flavor	Tea flavor	21 – 30
	Strong or faint tea flavor	11 – 20
	No tea flavor	0 – 10

Table 2   Variables and levels of the BBD for the formulation optimization
g

Variable	Level		
	– 1	0	1
Tea amount	20	25	30
Sugar amount	6	8	10
Flavor amount	0.8	1	1.2

3   Results and discussion

3.1   Single-factor experiment

The effect of tea amount on sensory score of peanuts was shown in Fig. 1. As demonstrated, the sensory score increased first and then decreased, with the increasing of tea amount. The sensory score peaked when the tea amount was 25 g.
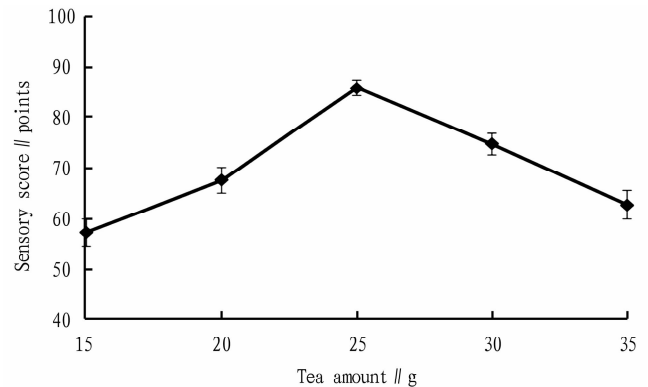

Fig. 1   Effects of tea amount on sensory score of peanuts

The effects of salt amount on sensory score of peanuts were shown in Fig. 2. It could be found that salt amount barely influ-

enced the sensory test of peanuts. The sensory score was highest and reached 84.8 points with adding 5 g salt.
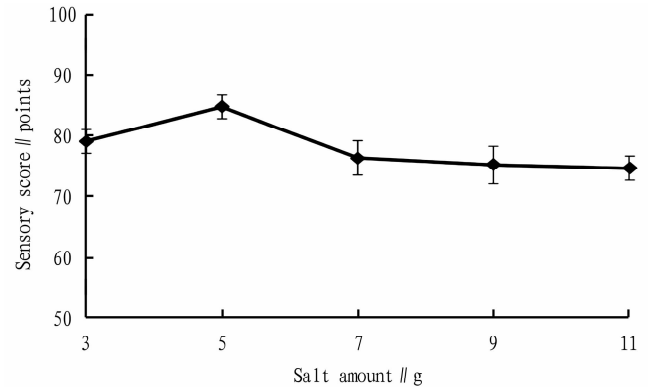

Fig. 2   Effects of salt amount on sensory score of peanuts

As shown in Fig. 3, the effects of sugar amount on sensory score of peanuts were similar to that of tea amount. The sensory score peaked and reached 84.2 points, when the sugar amount was 8 g.
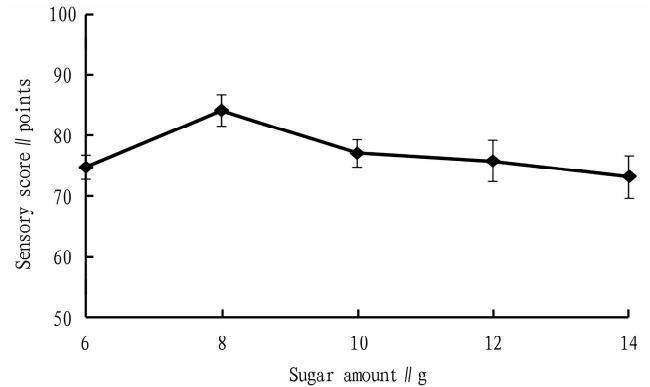

Fig. 3   Effects of sugar amount on sensory score of peanuts

The effects of tea flavor amount on sensory score of peanuts were shown in Fig. 4. As shown, the sensory score went up first but then it went down, when the flavor amount increased. The sensory score reached highest and was 86 points, with adding 1 g of tea flavor.
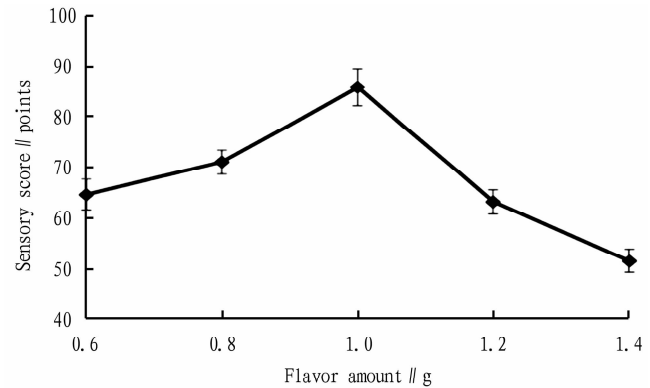

Fig. 4   Effects of flavor amount on sensory score of peanuts

The effects of cooking time on sensory score of peanuts were

shown in Fig. 5. The longer cooking time could help increase the sensor score of peanuts, while overcooking would lower the flavor score of peanuts. The optimal of cooking time was 50 min, and the sensor score reached 86. 9 points.
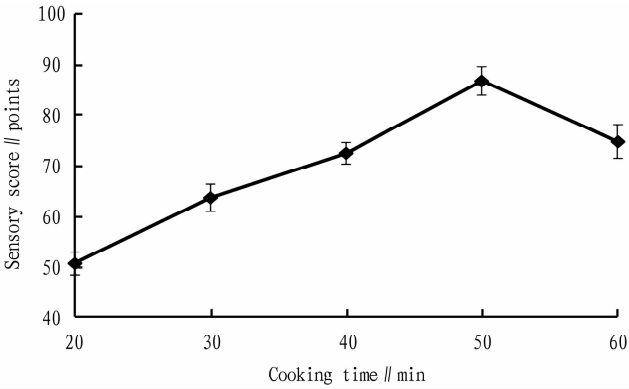

Fig. 5 Effect of cooking time on sensory score of peanuts

3.2 Response surface experiment analysis According to the preliminary experiment results, three factors were chosen to study their effects on the sensory evaluation (Y) of peanuts, including Tea amount (A), sugar amount (B) and flavor amount (C). The matrix of Box-Behnken design and results for 15 experiment runs are shown in Table 3.

Table 3 Matrix of Box-Behnken design and results for each experiment run

Run	A: Tea amount // g	B: Sugar amount // g	C: Flavor amount // g	Sensory score // points
1	20	6	1.0	81.6
2	30	6	1.0	74.7
3	20	10	1.0	63.6
4	30	10	1.0	69.6
5	20	8	1.2	83.1
6	30	8	1.2	77.9
7	20	8	0.8	59.9
8	30	8	0.8	66.4
9	25	6	1.2	85.6
10	25	10	1.2	73.2
11	25	6	0.8	69.6
12	25	10	0.8	57.7
13	25	8	1.0	90.3
14	25	8	1.0	93.6
15	25	8	1.0	92.3

The experimental data were fitted by a quadratic equation to reveal the relationship between the response variable and interdependent variables, which was demonstrated as follows:

$$Y = 89.20 - 3.19A - 3.67B - 0.337\,5C + 1.50AB + 1.72AC + 0.05BC - 5.29A^2 - 8.01B^2 - 4.44C^2$$

where Y is the sensory score. The correlation coefficient (R^2) was 99.60% that indicating the model fitted the variation well. The analysis of variance (ANOVA) for the model is shown in Table 4.

Based on Table 4, the F-value of the model was 137.67 and P value was less than 0.000 1, which implied the model is significant. In addition, the lack of fit F value and P value were 0.249 1 and 0.858 1, respectively, confirming the good fit and suitability of the model for the experiment results. The above results proved that the model could be used for the optimization the formulation.

Table 4 Statistical model summary for experimental data

Source	Sum of square	DOF	Mean square	F-value	P-value
Model	1 881.30	9	209.030	137.670	<0.000 1
A	0.020	1	0.020 0	0.013 2	0.913 1
B	280.85	1	280.85	184.67	<0.000 1
C	547.80	1	547.80	360.79	<0.000 1
AB	41.60	1	41.60	27.40	0.003 4
AC	34.22	1	34.22	22.54	0.005 1
BC	0.063	1	0.062 5	0.041 2	0.847 2
A^2	347.11	1	347.11	228.61	<0.000 1
B^2	368.92	1	368.92	242.98	<0.000 1
C^2	410.64	1	410.64	270.45	<0.000 1
Residual	7.59	5	1.52		
Lack of fit	2.06	3	0.688 3	0.2491	0.858 1
Pure error	5.53	2	2.76		
Total deviation	1 888.90	14			

In order to obtain more clear expression about the effects of the interaction of factors on the sensory evaluation, the 3D surface and contour plot are demonstrated in Fig. 6. It is very useful to find out different surface shapes for different variables and effectiveness on the sensory score. Similar to 3D surface plot, contour plot also unveil the interaction among variables which is more straightforward than the former[15]. The response surface attained by plotting the sugar amount versus tea amount, represented in Fig. 6A, shows a clear surface, suggesting that the optimum sensory score was well inside the design boundary. The sensory score demonstrated obvious first increasing and then decreasing with the increasing of both sugar amount and tea amount. The reason behind this was sugar and tea amount had comprehensive influence on the sensory evaluation of tablets. Since tea amount could contribute to the flavor of peanut but brought the harshness flavor. The response surface of the flavor amount versus tea amount and flavor amount versus sugar amount were shown in Fig. 6B and Fig. 6C, which is similar to Fig. 6A.

According to the model, the optimal formulation composition was 100 g peanuts, 500 mL of water, 25 g tea, 5 g salt, 8 g sugar and 1 g tea flavor with a sensory score of 94.3 points. As the most dominant factor affecting consumers' preference for foods, the sensory evaluation plays the key role in consumer appeal, purchasing decisions and ultimate consumption. Finally, we obtained the optimal formulation that has the maximum sensory score.
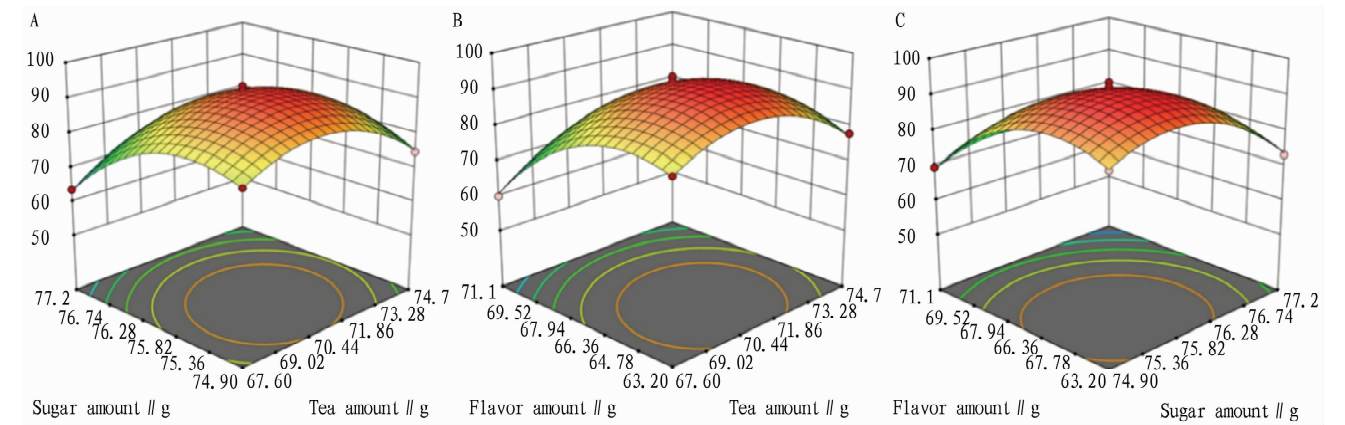
Fig. 6   Response surface of Box-Behnken design by plotting

4   Conclusions

    This study developed an optimal formulation of peanuts with Yingshan Yunwu tea flavor. Firstly, the single-factor experiment was performed to study all factors on the sensory score of the peanut, including tea amount, salt amount, sugar amount, flavor amount and cooking time. Then, response surface methodology with the Box-Behnken design were carried out, and the optimal formulation composition was 100 g peanuts, 500 mL of water, 25 g tea, 5 g salt, 8 g sugar and 1 g tea flavor with a sensory score of 94.3 points. In conclusion, the peanuts with Yingshan Yunwu tea flavor were generally acceptable by consumers.

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