Effects of Preservation using Response Surface Methodology on Fresh-cut Taro

SHI Shuai[1], XU hai-xiang[2], LI zhi-fang[3*]

Jiangsu Agri-Animal Husbandry Vocational College, Taizhou, China
[*3]Corresponding author, engaged in food science and technology related research

***Abstract*—** *In order to evaluate the effect of preservation on fresh-cut taro, the edible coatings preservatives were connected with Konjac glucan-mannan (KGM), potassium sorbate, chitosan, by determining changes of weight loss rate, browning degree (BD), polyphenol oxidase (PPO) and peroxidase (POD), the preservative effect on fresh-cut taro were studied. The optimal composite of Konjac glucan-mannan (KGM), potassium sorbate, chitosan was analyzed by single factor test and Box-Behnken response surface method. The results showed the optimal concentration were KGM 6g/L, potassium sorbate 4g/L and chitosan 8g/L. Verified test showed that composite coating could reduce the weight loss rate, browning, PPO and POD activity of fresh-cut taro.*

Keywords*— *fresh-cut taro; browning degree; response surface; Konjac glucan-mannan (KGM).

I. INTRODUCTION

Colocasia esculenta (L), also known as taro, its edible part is the main underground bulb. Like other fresh-cut products, fresh-cut taro is also very easy to brown during processing and storage, which seriously affects the commercial value of the product. Konjac glucomannan is a natural plant polysaccharide, which can be dissolved in water will form a highly viscous pseudoplastic solution. At present, the research on konjac glucomannan film coating in fresh fruits and vegetables has been reported, but composite coating preservation of konjac glucomannan on taro has not been reported. Chitosan is a polysaccharide biological macromolecule, which has the advantages of safe, non-toxic, film-forming and bacteriostatic, edible and biodegradable, and has been widely reported [1] in recent years. The preservative potassium sorbate used in food was used as strengthening agent [2]. The best combination of Konjac glucomannan, potassium sorbate and chitosan was screened by single factor experiment and response surface design-expert analysis, exploring its mechanism of action, And providing technical support and theoretical basis for the application of konjac glucomannan composite coating film in taro storage and preservation.

II. MATERIAL AND METHOD

2.1 Materials and Reagents

2.1.1 Main raw material

Taking individual integrity, normal color, no damage longxiang taro, bought in taizhou.

Konjac glucomannan (KGM) : hefei bomei biotechnology co., LTD. Potassium sorbate: food grade, wang long group co. LTD. Chitosan: food grade, yunsheng biotechnology co. LTD.

2.1.2 Main instruments and equipment

GYB series high pressure homogenizer: Shanghai donghua high pressure homogenous machine factory; Slicer: yantai haidu food machinery co., LTD. Knives, stainless steel basins, preservation cabinets, etc.

2.2 Experimental methods

2.2.1 The single anti-browning agent used to inhibit the browning of taro

After the skin was peeled, it was cut into thin slices of 3~4 mm thick by slicing machine and randomly divided into 4 groups, respectively using distilled water (control) and KGM (concentration of 2, 4, 6, 8, 10.0 g/L respectively), edible chitosan(concentration of 6, 8, 10, 12, 14 g/L respectively) and potassium sorbate (concentration of 2, 4, 6, 8, 10.0 g/L respectively) solution for 5 min, after natural air at room temperature, placed in 4℃fresh-keeping cabinet storage, every 2 d to determine indicators.

Based on single factor experiment, three anti-browning agents KGM, chitosan and potassium sorbate were optimized by using the box-Behnken center combined experimental design. The experimental factors and horizontal design are shown in table 1[3].

TABLE 1
THE OPTIMIZATION FACTORS AND LEVEL OF RESPONSE SURFACE

level	factors		
	A:KGM concentration (g/L)	B:chitosan concentration (g/L)	C:Potassium sorbate (g/L)
1	4	8	4
2	6	10	6
3	8	12	8

2.2.2 Indicators Determination

Browning degree: With reference to the method of the Su xin guo[4], represented by $OD_{410}\times100$;

Activity of polyphenol oxidase (PPO): by using catechol method [5], an enzyme activity unit (U) was increased by 0.01 in OD_{398} 1min;

Activity of Peroxidase (POD) : the use of guaiacol[6] increased by 0.01 in OD_{470} 1min to 1 enzyme activity unit (U).

The above indexes were repeated 3 times

III. RESULTS AND ANALYSIS

3.1 Single factor experiment

3.1.1 Effect of chitosan on the browning of fresh-cut taro

As can be seen from figure 1, the browning degree of fresh-cut taro was increasing continuously during storage. In the control group, the Browning of the 1d was increased, until 6d, the tangent plane was severely browned, and the browning degree reached 9.2, which was 3.47 times higher than the beginning and lost the quality of food. The browning degree of the fresh-cut taro treated with chitosan coating was significantly less than that of the control group ($p<0.05$), and the group of 6 g/L chitosan also reached 8.7 in the 8d. After comprehensive consideration, the optimal chitosan concentration was selected 12 g/L.

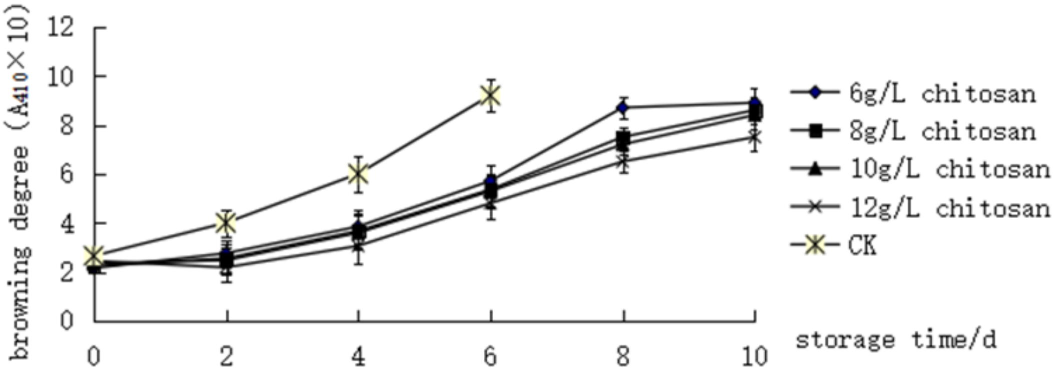


FIGURE 1: EFFECT OF CHITOSAN ON THE PRESERVATION

3.1.2 Effect of potassium sorbate on the browning of fresh-cut taro.

As can be seen from figure 2, the browning degree was increased gradually with the extension of storage time. The browning degree of fresh-cut taro treated with potassium sorbate was significantly less than that of control. In 4, 6, 8, 10 g/L potassium sorbate treatment group can be better inhibiting browning of taro, which may be the potassium sorbate as anti browning agents interfere with enzymatic browning reaction [7], eventually led to the effect of inhibiting browning. The group of 10 g/L sorbate treatment was not significantly different from the other 3 groups (*$p>0.05$*). In terms of economy, the group of 8 g/L was selected as the optimum level for composite coating composite response surface

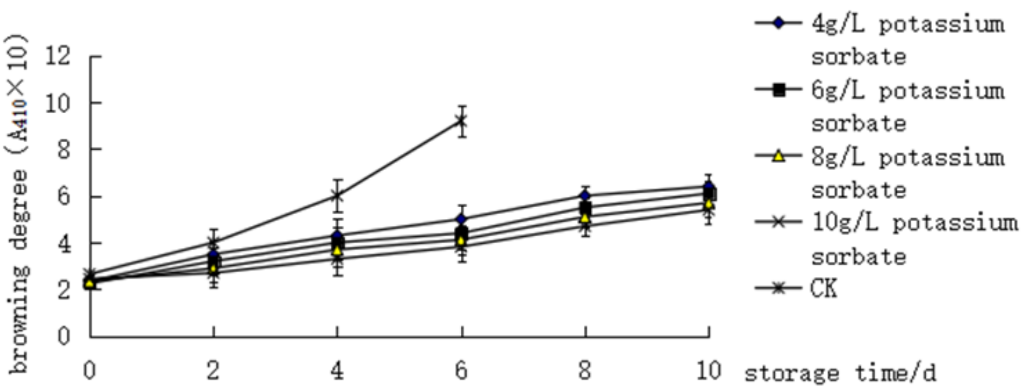


FIGURE 2: EFFECT OF POTASSIUM SORBATE ON THE PRESERVATION

3.1.3 Effect of KGM on browning of fresh-cut taro

As can be seen from figure 3, compared with the treatment group, the browning degree of the control group was significantly increased, and the browning had already occurred in the storage of 1d. The browning degree of KGM was slowly rising. It may be that KGM deals with a thin film on the surface of the taro to isolate the contact between polyphenol oxidase and O_2[8,9]. Among them, the group of 6 g/L had better preservation effect than other groups.

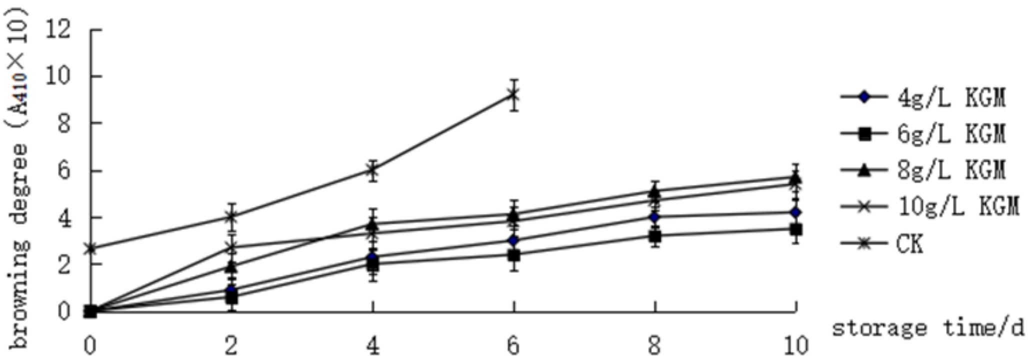


FIGURE 3: EFFECT OF KGM ON THE PRESERVATION

3.2 The response surface test of optimized composite combination

Based on the single factor, the optimization composition of preservation process was carried out, and the results of response surface test were shown in table 2, and the regression analysis was shown in table 3.

TABLE 2
THE OPTIMAL COMPOSITION OF PRESERVATION TESTED IN RESPONSE SURFACE ANALYSIS

Test	A KGM concentration (g/L)	B chitosan concentration (g/L)	C Potassium sorbate (g/L)	Browning degree
1	0(6)	1	-1(4)	4.13
2	1(8)	-1(8)	0(6)	4.25
3	0	-1	-1	2.04
4	-1(8)	1(12)	0	4.87
5	0	0(10)	0	1.15
6	0	0	0	1.17
7	0	0	0	1.11
8	-1	0	-1	1.67
9	1	1	0	4.05
10	0	0	0	1.19
11	-1	-1	0	3.17
12	1	0	-1	6.00
13	-1	0	1(8)	4.28
14	0	-1	1	3.05
15	0	1	1	6.87
16	0	0	0	1.16
17	1	0	1	6.47

Table 2 can be obtained after regression fitting:

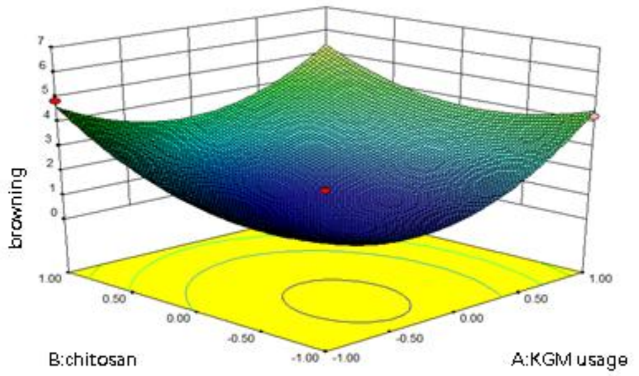
$Y=5.15+0.76A+1.59B+0.85C-0.30AB-0.54AC+0.43BC-0.90A^2-1.49B^2+0.36C^2$.

TABLE 3
EXPERIMENTAL DESIGN AND RESULTS FOR RESPONSE SURFACE ANALYSIS

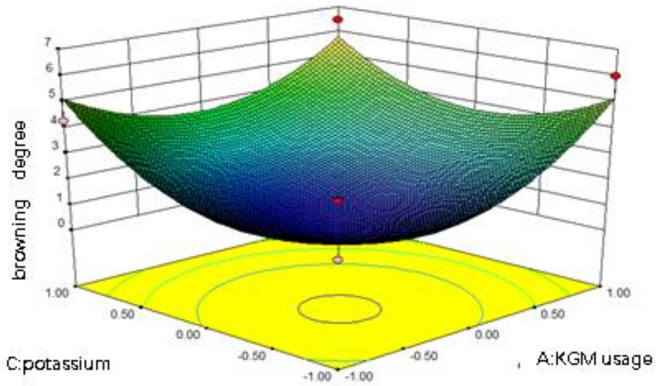
Project	sum of squares	freedom	mean square	F value	P value	significant
model	46.49	9.00	5.17	5.82	0.015	*
A	4.62	1.00	4.62	5.21	＜0.0001	**
B	20.19	1.00	20.19	22.76	0.0020	**
C	5.83	1.00	5.83	6.57	0.03	**
AB	0.36	1.00	0.36	0.41	0.54	
AC	1.14	1.00	1.14	1.29	0.29	
BC	0.75	1.00	0.75	0.84	0.39	
A^2	0.19	1.00	0.19	0.27	0.04	*
B^2	9.30	1.00	9.30	10.48	0.01	*
C^2	9.19	1.00	9.19	12.79	＜0.0001	**
residual	5.03	7.00	0.72			
loss item	3.85	3.00	1.28	4.37	0.09	
net error	1.18	4	0.29			
Correction term	52.70	16				

Note:* the influence was significant, P<0.05; ** the influence was very significant, P < 0.01.

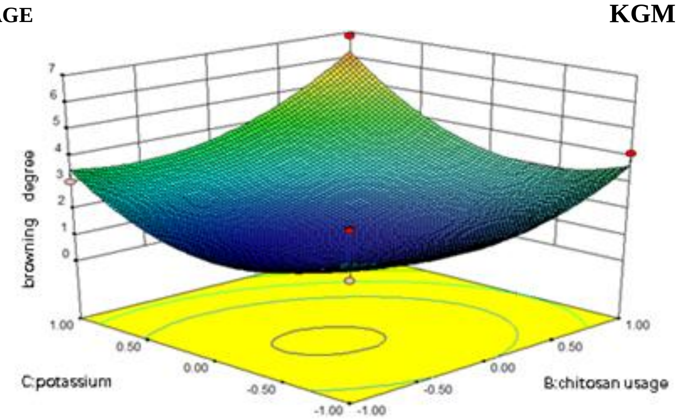
As can be seen from table 3, the model had a significant one, and the quadratic term A^2, B^2 and C^2 were significant. The F value of the model was 5.82, and the significant level of the overall model was $P< 0.05$, indicating that the model was significant. The model $R^2 = 0.9647$ indicates that the regression equation has a good fitting degree and a smaller loss, which can be used to substitute the real test point for analysis. According to the obtained mathematical model, the response surface diagram was drawn, as shown in figure 4.



A. THE INTERACTION OF CHITOSAN USAGE AND KGM USAGE



B. THE INTERACTION OF POTASSIUM SORBATE USAGE AND KGM USAGE



C. THE INTERACTION OF POTASSIUM SORBATE USAGE AND CHITOSAN USAGE

FIG.4 THE RESPONSE OF THE TWO INTERACTING FACTORS ON BROWNING DEGREE AND CONTOUR MAP

Potassium sorbate, chitosan and KGM interaction of taro had influence on browning degree of coating preservation, especially the dosage of KGM was obvious, which affected by the interaction of KGM and chitosan usage, in response to the surface map, which showed a large gradient, changed significantly (figure 4).

3.3 Optimization of Compound Preservative

After the analysis of the boundary value and the obtained extremum by the design-expert software, the optimal conditions for each factor obtained were 8 g/L of chitosan, 4.34 g/L of potassium sorbate, and KGM5.83 g/L, and the predicted browning value was 3.26 under this condition. Considering the actual operation, the above conditions were modified as: chitosan 8 g/L, potassium sorbate 4 g/L, KGM6 g/L.

The experimental results showed that the browning degree was 3.14 and the prediction accuracy was as high as 96.31% in the best condition of correction, and the accuracy of regression model was proved again.

3.4 The preservative effect of KGM composite coating on taro

3.4.1 Effect of KGM composite coating on the loss weight of fresh-cut taro

As can be seen from figure 5, the quality loss rate of the control group (CK) was increased rapidly during storage, and the change was positively correlated with the storage time.

The mass loss of control treatment and KGM composite coating on taro were 8.02%, 5.20% respectively when storage 6 d, which may be chitosan in composite KGM coating in fresh-cut taro surface film to prevent moisture evaporate[10]. It was proved that the treatment of KGM composite coating could effectively reduce the quality loss of taro.

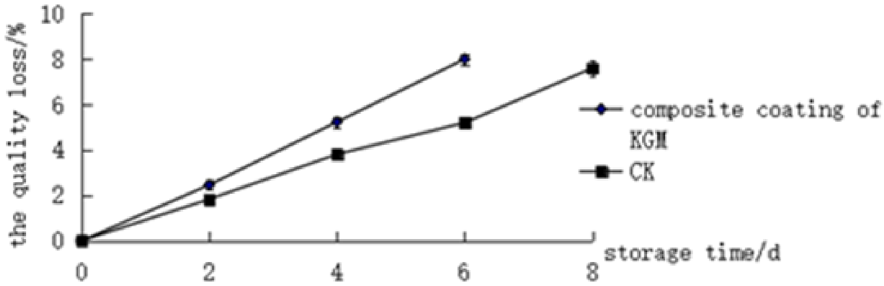


FIGURE 5: EFFECT OF KGM COMPOSITE COATING ON THE QUALITY LOSS OF FRESH-CUT TARO

3.4.2 Effect of KGM composite coating on PPO activity of fresh-cut taro

As can be seen from figure 6, the PPO activity of taro was rising continuously during storage. In contrast (CK), the growth rate of KGM composite coating was slow. In storage of 10d, the PPO activity of the coating group was 18.93 U/g than the control group (25.78 U/g), which may be due to the effect of moderate ascorbic acid in the PPO reaction system. It can be seen that composite coating of KGM could reduce the PPO activity that triggered the enzymatic reaction.

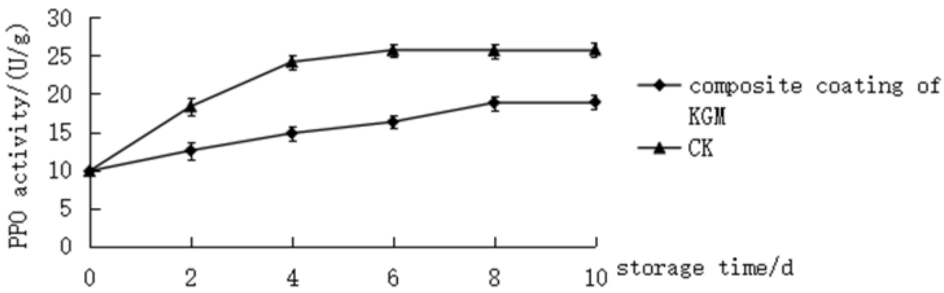


FIGURE 6: EFFECT OF KGM COMPOSITE COATING ON PPO ACTIVITY OF FRESH-CUT TARO

3.4.3 Effect of KGM composite coating on POD activity of fresh-cut taro

It can be seen from figure 7 that the POD activity of taro was increased with the increase of storage time. When the taro storage was 8d, the POD activity of control (CK) increased by 9.8 times, and the POD activity of KGM composite coating was 12.85u /g, which was 60.32% lower than the control group. It can be seen that KGM composite coating could effectively inhibit POD activity.

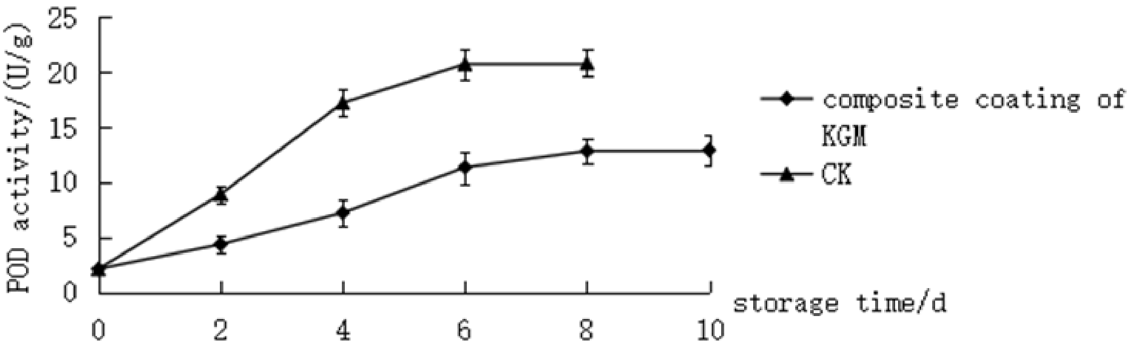


FIGURE 7: EFFECT OF KGM COMPOSITE COATING ON POD ACTIVITY OF FRESH-CUT TARO

IV. CONCLUSION

Through the quadratic polynomial regression equation model, the optimal proportion of KGM composite film was ethyl chitosan 8 g/L, potassium sorbate 4 g/L, KGM 6 g/L, composite coating treatment on taro could reduce the quality loss, slow browning, the inhibition of PPO and POD activity.

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