

# Two-rotation Orthogonal Combination Design Optimizes the Process Parameters of Fresh-cut Rosa Green

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**Abstract.** In order to improve product quality, extend the shelf life of fresh-cut Rosa green, and reduce the loss rate of processing and circulation, the secondary rotation-orthogonal composite design is used to optimize the process parameters of ready-to-eat fresh-cut Rosa green. The results showed that weight loss rate, conductivity, POD, Vc, total number of colonies, nitrite, and chromaticity value  $a$  were significantly correlated with storage time ( $p < 0.01$ ). Principal component analysis showed that the two principal components accounted for 96.215% of the contribution rate. Fresh cut Rosa green quality evaluation value comprehensive value  $Y = -0.371$  Chromaticity value  $a - 0.373$  Weight loss rate  $-0.357$  Total number of colonies  $-0.005$  POD  $+ 0.374$  Vc  $- 0.333$  Relative conductivity  $- 0.269$  Nitrite. The secondary disinfection sodium hypochlorite concentration, the ratio of  $O_2$  (v / v) and  $CO_2$  (v / v) and the storage temperature were studied to influence the comprehensive quality of fresh cut Rosa green during storage. The results showed that the optimal process parameters were: secondary disinfection sodium hypochlorite concentration was 31.43ppm,  $O_2$  concentration was 3.04%,  $CO_2$  concentration was 5.55%, and storage temperature was 3.68°C. Fresh cut Rosa green processed under the optimum process parameters can be stored for 15 days. This study has positive significance for the post-harvest processing of fresh cut Rosa green.

## 1. Introduction

Rosa green is a leafy lettuce. Widely planted all over the world and loved by consumers. It contains a variety of camp substances and antioxidants, which can promote blood circulation and diuretic effect in the body.

In order to avoid the problem of rottenness and browning caused by improper technology during the processing of fresh Rosa Green, reduce the loss rate, ensure that fresh-cut Rosa Green has good quality in circulation, and maintain an appropriate degree of freshness. It is necessary to optimize the key processes of fresh-cut Rosa Green during processing.

## 2. Materials and Methods

### 2.1. Materials and Sample Preparation

Fresh-cut Rosa Green after 110ppm sodium hypochlorite disinfection solution and air-packing treatment is used as a key indicator to evaluate the shelf life. Untreated Rosa Green is used to optimize the process parameters of fresh-cut Rosa Green. All Rosa greens are supplied by the Yang zhen base of Beijing Yu nong Quality Agricultural Products Planting Company. Harvested in the morning and shipped to the laboratory throughout the cold chain within 3 hours. Pack 50g of Rosa green high density polyethylene film (HDPE, length 290mm, width 280mm, film thickness 37.1 $\mu$ m, air permeability coefficient:  $CO_2$   $4.5 \times 10^4$ ,  $O_2$   $2.6 \times 10^4$ ,  $N_2$   $2.2 \times 10^{-2}$ ), seal and place Store at 4 °C. Rosa



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green filled with air was placed in the refrigerator as a control group, and samples were taken and tested every 2 days.

## 2.2. Experiment Method

With reference to the method of AGÜERO et al. 10 professionals were evaluated from various aspects such as color, odor, and organization status[1]. The weight loss rate was measured according to the method of Rebogile et al[2]. The relative conductivity was measured according to the method of Agüero et al. the PPO was measured according to the method of Min Li et al[3]. Dichloroindophenol titration method for determination of vitamin C, Shi-peng Liu et al[4]. For determination of SOD, portable handheld refractometer for total soluble solids, GB 4789.2-2016 for determination of total colony count, Determination of nitrite, determination of soluble protein by the method of He-sheng Li, et al. Measurement of the color of Rosa green (L, a \*, b \*) using the DC-P3 full-automatic colorimeter, and determination of CO<sub>2</sub> using a fruit and vegetable respirometer Concentration, calculate the breathing rate[5].

## 2.3. Secondary Rotation-Orthogonal Compound Experimental Design

In order to optimize the fresh-cut Rosa green processing technology, the key steps and factors that affect its quality are selected: secondary disinfection sodium hypochlorite concentration, spin-drying time, ratio of O<sub>2</sub> and CO<sub>2</sub>, and storage temperature as factors. Cross compound experimental design (Table 1) set 5 levels for each factor.

**Table 1.** Five-factor quadratic regression orthogonal rotation combination test design factor horizontal coding table

coding	X1 Degree of sodium hypochlorite (ppm)	X2 Drying time (S)	X3 O <sub>2</sub> ratio (%)	X4 CO <sub>2</sub> ratio (%)	X5 Storage temperature
2	60	90	6	10	32
1	45	75	4.5	7.5	24
0	30	60	3	5	16
-1	15	45	1.5	2.5	8
-2	0	30	0	0	0

## 2.4. Data Analysis

Correlation analysis and principal component analysis were performed using SPSS 19.0. Model significance was evaluated using DPS.

## 3. Results and Discussion

### 3.1. Determination of Fresh-Cut Rosa Green Indicators during Storage

It can be seen from Table 2. The sensory quality of fresh-cut rosa green showed a downward trend, and the decline trend was larger after 4 days, indicating that the quality of fresh-cut rosa green began to deteriorate after 4 days. As the storage time increases, the color of fresh-cut vegetables begins to darken and brown. Relative conductance increased at 2-6d, and cell membrane integrity was impaired. During storage, the respiratory rate showed an increasing trend, and the total number of colonies gradually increased, resulting in a continuous increase in the nitrite content in fresh-cut Rosa green. PPO is one of the main enzymes that cause enzymatic browning of lettuce. During storage, PPO and SOD showed a downward trend, and PPO activity in leaf veins was 5.7 times that in leaves. POD is on the rise, and the browning potential is highly correlated with POD activity. Protein content is closely related to plant senescence, and is an important indicator for measuring the total metabolism of plants. The soluble protein content at 10d decreased by 67% compared with the starting point of storage, indicating that fresh-cut Rosa green began to age during storage, the protein decomposition rate was high, and the protein content showed a downward trend.

**Table 2.** Changes in Fresh-Cut Rosa Green Index Values During Storage

Storage time (d)	Sensory analysis	Weight loss (%)	Relative conductivity (%)	POD (U/g)	Vc (mg/g)	SOD (U/g)	Respiratory rate (mg CO <sub>2</sub> ·g <sup>-1</sup> ·h <sup>-1</sup> )	Total colony (log CFU/g)	L	b *	a *	PPO (U/g)	Nitrite (μmol·g <sup>-1</sup> )	Soluble solids (%)	Soluble protein (mg/g)
0	9	0	7.2	90.3	7.6	243.3	16.7	3.8	56.9	34.2	19.1	247.3	0.36	0.87	16.95
2	8.6	1.5	11.3	89.7	6.87	148.7	13.4	3.9	56.7	34.9	16.3	176.4	0.61	0.92	17.6
4	7.9	2	12.4	92.1	6.52	271.2	14.1	4.2	56.4	34.7	17.2	261.6	1.52	1	17.37
6	6.2	3.2	12.9	109.8	5.63	121.5	17.3	4.8	54.3	34.8	15.7	149.8	1.83	0.93	18
8	4.9	4.6	17.1	129.8	4.71	87.2	17.1	6.6	53.1	35.4	14.4	87.5	2.47	0.83	22.08
10	3.3	5.1	25.2	168.3	4.32	44.9	24.3	8.1	51.2	36.3	13.8	52.3	3.43	0.74	27.33

### 3.2. Correlation Analysis between Indicators of Fresh-Cut Rosa Green and Shelf Life

Correlation analysis between fresh-cut Rosa green indicators and storage time was performed by SPSS. The Pearson correlation coefficient ranged from -1 to 1. The larger the absolute value, the stronger the correlation. From Table 3, it can be seen that the storage time is extremely significantly related to weight loss rate, electrical conductivity, POD, Vc, total number of colonies, nitrite, a value ( $p < 0.01$ ), and sensory PPO, SOD, soluble solids, soluble proteins, The values were significantly correlated ( $p < 0.05$ ) and were not related to L value and respiratory rate. Sort the extremely significant shelf-life related indicators: weight loss rate > total number of colonies > POD > Vc > conductivity > nitrite > a value.

**Table 3.** Correlation between the indicators of fresh cut Rosa green and shelf life

	Storage time	Sensory analysis	Weight loss	Relative conductivity	PPO	POD	VC	SOD	Soluble solids	Soluble protein	Total colony	Nitrite	L	a	b	Respiratory rate
Storage time	Pearson Relevance	1	-.953	-.997	-.968	-.916	-.977	-.974	-.956	.927	-.923	-.979	.962	-.481	.954	.962
	Saliency		*	**	**	*	**	**	*	*	*	**	**	**	*	

### 3.3. Establishment of Fresh-cut Rosa Green Evaluation System

It can be known from Table 4 that two principal components can be obtained through principal component analysis, and the cumulative contribution rate is 96.215%, indicating that these two principal components represent almost all the information.

**Table 4.** Total variance of key indicators of fresh cut Rosa green

Ingredients	Initial eigenvalue			Extract square sum load		
	total	variance%	accumulation %	total	variance%	accumulation %
1	5.645	80.644	80.644	5.645	80.644	80.644
2	1.090	15.571	96.215	1.090	15.571	96.215
3	0.210	3.003	99.218			
4	0.055	0.782	100.000			
5	$1.94 \times 10^{-16}$	$2.774 \times 10^{-15}$	100.000			
6	$-7.18 \times 10^{-17}$	$-1.026 \times 10^{-15}$	100.000			
7	$-2.84 \times 10^{-16}$	$-4.061 \times 10^{-15}$	100.000			

The principal component analysis showed that: principal component 1 = 0.414 b + 0.408 c - 0.162 d - 0.398 e + 0.415 f + 0.401 a + 0.378 g; principal component 2 = 0.1601 b + 0.0957 c + 0.872 d - 0.249 e - 0.089 f + 0.213 a - 0.297 g. Comprehensive score at different storage times = -0.838 principal component 1 - 0.162 principal component 2 to obtain the comprehensive value of the fresh-cut Rosa Green evaluation system at different storage times  $Q = -0.371 a - 0.373 b - 0.357 c - 0.005 d + 0.374 e - 0.333 f - 0.269 g$  (a—color value a; b—weight loss rate; c—total colony; d—POD; e—Vc;

f—conductivity; g—nitrite).

It can be seen from Table 5 that the overall score of the fresh-cut Rosa Green evaluation system is positive and decreases with time. The comprehensive score of the Fresh-cut Rosa Green Evaluation System is 0.625 at 0d, and drops to 0.457 at 8d, and the sensory evaluation shows 8d Losing the value of the product, you can get a good value for the fresh-cut Rosa Green with a comprehensive value between 0.457 and 0.625. The lower the comprehensive value, the better the quality.

**Table 5.** Comprehensive evaluation value of fresh cut Rosa green during the shelf life

Storage time	Main component 1	Main component 2	Comprehensive value
0	-1.131	1.99	0.625
2	-1.10	2.04	0.588
4	-1.08	2.10	0.560
6	-1.068	2.12	0.518
8	-0.878	1.70	0.457

### 3.4. Significance Test of Two Regression Models

The DPS data processing system was used to perform quadratic regression rotation fitting on the experimental data. As can be seen from the analysis of variance in Table 6, the total regression reached a significant level, which proved that the experiment was effective. From the test results,  $x_1$ ,  $x_2$ ,  $x_3$ , and  $x_4$  'are all less than 1, indicating hat the effect is not significant. The FLF obtained through the fitness test is less than 1, indicating that the equation has a good fit. The F value shown in Table 7 shows that the model is extremely significant ( $p < 0.01$ ), and the comprehensive value of fresh-cut Rosa green was accurately predicted on the 4th day.

The regression model is:

$$Y = -0.5843 - 0.0017X_4 + 0.003X_5 + 0.0049X_1X_2 + 0.00199X_1X_3 + 0.0031X_1X_4 + 0.0165X_1X_5 + 0.0057X_2X_3 - 0.0031X_2X_4 + 0.0011X_2X_5 - 0.0011X_3X_4 + 0.0027X_3X_5 + 0.005X_4X_5 - 0.0039X_{12} - 0.0094X_{22} + 0.0034X_{32} + 0.0073X_{42}$$

The results showed that the storage temperature had a significant effect on the comprehensive value of fresh-cut Rosa green during storage ( $p < 0.01$ ). The order of the effects of the five processes on the quality of fresh-cut Rosa green was storage temperature > CO<sub>2</sub> ratio > drying time > O<sub>2</sub> ratio > secondary disinfection sodium hypochlorite concentration.

**Table 6.** Variance analysis of five-element quadratic orthogonal rotation combination design for fresh-cut Rosa green processing optimization experiment

project	sum of squares(SS) $\times 10^{-4}$	Degrees of freedom(df)	Mean square(MS) $\times 10^{-4}$	F value	Saliency
x <sub>1</sub>	0.00865	1	0.00865	<1	ns
x <sub>2</sub>	0.0792	1	0.0792	<1	ns
x <sub>3</sub>	0.0402	1	0.0402	<1	ns
x <sub>4</sub>	0.718	1	0.718	8.21*	p<0.5
x <sub>5</sub>	2.24	1	2.24	25.6**	p<0.01
x <sub>1</sub> x <sub>2</sub>	3.87	1	3.87	44.3**	p<0.01
x <sub>1</sub> x <sub>3</sub>	0.639	1	0.639	7.30*	p<0.5
x <sub>1</sub> x <sub>4</sub>	1.54	1	1.54	17.6**	p<0.01
x <sub>1</sub> x <sub>5</sub>	43.6	1	43.6	499**	p<0.01
x <sub>2</sub> x <sub>3</sub>	5.2	1	5.2	59.4**	p<0.01
x <sub>2</sub> x <sub>4</sub>	1.59	1	1.59	18.2**	p<0.01
x <sub>2</sub> x <sub>5</sub>	0.217	1	0.217	2.49	
x <sub>3</sub> x <sub>4</sub>	0.197	1	0.197	2.25	
x <sub>3</sub> x <sub>5</sub>	1.25	1	1.25	14.3**	p<0.01
x <sub>4</sub> x <sub>5</sub>	4.27	1	4.27	48.8**	p<0.01
x <sub>1</sub> '	4.67	1	4.67	53.3**	p<0.01
x <sub>2</sub> '	26.7	1	26.7	305**	p<0.01
x <sub>3</sub> '	3.66	1	3.66	41.7**	p<0.01
x <sub>4</sub> '	0.0482	1	0.0482	<1	ns
x <sub>5</sub> '	16.2	1	16.2	185**	p<0.01
return(SS <sub>R</sub> )	5.79	20	0.289	3.31*	p<0.5
Remaining(SS <sub>r</sub> )	0.963	11	0.0875		
error(SS <sub>e</sub> )	0.0153	5	0.00305	<1	ns
Lack of fit(SS <sub>LF</sub> )	0.947	6	0.158	<1	ns
Total return(SS <sub>y</sub> )	6.75	31			

Note: ns means the difference is not significant, \* means significant, \*\* means extremely significant

### 3.5. Optimal Parameter Combinations

The optimal solution is calculated by using the comprehensive value of 4d: x<sub>1</sub> = 0.0477, x<sub>2</sub> = -0.0036, x<sub>3</sub> = 0.0129, x<sub>4</sub> = 0.111, x<sub>5</sub> = -1.5397 The best process for processing and storing fresh-cut Rosa green is obtained: secondary disinfection sodium hypochlorite The concentration was 31.43ppm, the drying time was 59.89s, the O<sub>2</sub> concentration was 3.04%, the CO<sub>2</sub> concentration was 5.55%, and the storage temperature was 3.68°C.

## 4. Conclusion

The weight loss rate, relative conductivity, POD enzyme activity, Vc content, the total number of colonies, nitrite, and a value were extremely significantly correlated with the storage time in the previous indicators. Comprehensive value = -0.371 a value -0.373 weight loss rate -0.357 total colony -0.005 POD +0.374 Vc -0.333 relative conductivity -0.269 nitrite. Different factors will interact and affect the shelf life of fresh-cut Rosa Green. The best fresh-cut technology and storage conditions for Rosa Green are established by calculation and calculation: the concentration of sodium hypochlorite in secondary disinfection is 31.43ppm, and the drying time is 59.89s. The O<sub>2</sub> concentration was 3.04%, the CO<sub>2</sub> concentration was 5.55%, and the storage temperature was 3.68°C. It can be stored up to 15

days through processing under optimal conditions. The comprehensive evaluation value is 0.449, which still has commercial value, which is 7 days higher than the original process.

## 5. References

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