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Effect of coating treatments on the extension of the shelf-life of minimally processed cucumber

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A b s t r a c t. Minimally processed fruits and vegetables caused the emergence of a new plant processing industry in the world. The physiological and physical changes in cucumber were studied after treating with edible films coating and ozone water. The study showed that the concentration of 4.2 mg m^{-3} ozone and the C treatment (polyvinyl alcohol 134 (1%); chitosan (1%); lithium chloride (0.5%); glacial acetic acid (2.5%); sodium benzoate (0.05%)) with a combined coating inhibits respiration and chlorophyll breakdown. Furthermore, it can also lower the soluble solids content and inhibit the polyphenol oxidases (PPO) activity.

K e y w o r d s: minimally processed cucumber, ozone, coating, preservation

INTRODUCTION

Minimally processed (MP) fruits and vegetables have become popular because of the increased consumption of fast food and prepared salads. MP fruits and vegetables are convenient, nutritious, and have a fresh quality (Church, 1994). The technology for processing them involves the minimum of preparation such as peeling, cutting, trimming, sectioning, slicing and coring. To satisfy increasing consumer interest in ready-to-use vegetables, extensive research on 'minimum process' technology needs to be performed in order to extend the shelf-life of those products (Huxsoll and Bolin, 1998).

However, the major problem with MP fruits and vegetables is their highly perishable nature during storage. They are generally more perishable than materials of the same variety which have not been touched (Huxsoll and Bolin,1989; Rolle and Chism,1987). While undergoing MP conditions, the cutting action damages the cells, allowing enzymes to intermix with substrates. The respiration and the increase in ethylene production hasten senescence. The texture and colour are altered due to the increased activity of naturally occurring enzymes such as chlorophyllase, pectinase, cellulases, esterases, polyphenol oxidases (PPO) and peroxidases (Jones *et al*., 1963). So, minimally processed (MP) products may suffer several degrading reactions, severe colour changes in particular, leading to a loss of freshness. Controlling the browning of MP fruit is an essential step in marketing them successfully.

The present research is limited to several varieties of fruit, such as the pineapple, apple, etc. (Corona *et al*., 2001). Fruit is usually sold having been peeled, cored and sliced for convenience, providing high nutritional value with a fresh appearance and ready for consumption. Extensive information is available on the use of chemical additives to reduce browning (Ghaoouth *et al*., 1991; Shen *et al*., 2000; Wang *et al*., 2001), edible coatings (Baldwin *et al*.,1995), and combined techniques that take advantage of the synergy of the various preservation techniques (Huxsoll and Bolin, 1989; Huxsoll *et al*., 1989; Nicolas *et al*., 1994).

The cucumber (*Cucumis sativus* L.) is an important vegetable in the world, which can be used in prepared vegetables in China. But it is very perishable, especially after cutting, and its shelf-life in supermarkets is limited to 2~3 days. However, to date there has been little research on it. The aim of the present work is to evaluate the effects of edible coating on the cucumber and to investigate the change in the degree of preservation during shelf-life. Based on this, an optimum coating technology for minimally processed cucumber can be obtained.

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MATERIALS AND METHODS

Treatments and shelf-life extension conditions

Fresh cucumbers were picked from a local farm in Suzhou, in Jiangsu province, China. The variety of cucumber used for the tests was Jingzha No. 2.

Cucumbers stored under refrigeration condition (4±0.5°C) were transported to the laboratory in batches of about 8 kg, all randomly selected. The cucumbers were first washed with chlorinated water (150 ppm of active chlorine for 5 min) to remove surface contamination. Then they were cut into pieces of 1.2x0.8x0.4 cm size. The procedure for testing the extension of the shelf-life of the cucumbers was carried out as in Fig. 1.

The substances and proportion of coating were composed as follows: 1) Treatment A: polyvinyl alcohol 134 (2%), monostearatacylglycerol (0.5%), phytic acid (0.05%), sorbitol (0.05%), sodium alginate (0.1%), absolute alcohol (8%); 2) Treatment B: polyvinyl alcohol 134 (1%), soluble starch (1%), glucose (1%), sucrose (1%), sodium alginate (0.1%), sorbitol (0.05%); 3) Treatment C: polyvinyl alcohol 134 (1%), chitosan (1%), lithium chloride (0.5%), glacial acetic acid (2.5%), sodium benzoate (0.05%). The above substances were mixed together and dissolved in pure water, then the mixture was heated to boiling and cooled to 45~55°C. The solution thus formed was used to coat the cucumber surfaces. PVC film packing of bag type, 200x300 cm in size, was sealed and used in the tests.

For the control samples, two contrasts were set up: i) C.K (check experiments) was treated only with 4.2 mg m^{-3} ozone water, packaged and stored at 4°C±0.5°, ii) C.K' without packaging or having been treated, just stored at room temperature.

For the organoleptic assessment of minimally processed cucumber during storage, three grades were set as follows: 1) good – almost the same as a fresh sample, 2) acceptable – slightly changed in colour, flavour, taste, shape etc., 3) rejected – largely changed in colour, flavour, taste, shape etc.

Quality attributes of storage

Weight loss was calculated from the weight of the cucumber before and after storage on the shelf. The respiration rate was measured by means of the standard method which uses NaOH to titrate in order to calculate the concentration of released CO_2. The 2.6-dichlorophenol indopenol method was used to determine the vitamin C content (Ranken *et al*., 1997). The traditional method, Fehlings Test (Zhang, 1999), was adopted for measuring the change of soluble sugar content. Titrable acidity was expressed as a percentage of malic acid. The pH value was measured by a pH-meter. The acid content was measured by potentiometric titration. The pH of ultimate titration is 8.1. The spectrophotometry method was adopted for measuring the chlorophyll content and the activity of PPO. The spectrophotometer used for the tests was a 721-type made in Shanghai, China.

Statistical analysis was carried out in triplicate and the mean values were compared using Duncan's multiple range tests, by SPSS program version 10.0 statistical software, at P value <0.05 to be significant.

RESULTS AND DISCUSSION

Weight loss

The respiration and transpiration of fresh produce can be expressed by the change in its weight (weight loss). Weight loss takes place with the extension of storage time. Weight loss was expressed as a percentage of the initial weight of the cucumber cubes. The effects of the different treatments on the weight loss are shown in Table 1. Overall weight loss was greater in C.K and C.K' compared to A, B and C treatments, showing that all three treatments are of benefit in controlling weight loss during storage. The C treatment had the best effect.

Respiration rate

The respiration of cucumbers obviously increases after harvest, which is intensely related to the biological reactions. Therefore, it can affect the quality of the cucumber during storage periods. The results are shown in Fig. 2 which shows that respiration was inhibited to a different extent after coating. In contrast with the C.K and C.K', treatment C had the best effect, where the amount of change was the smallest. Furthermore, the results of C.K were better than that of C.K', which shows that ozone can also inhibit respiration of cucumbers.

Acid content

Acid content is one of the most important factors in determining cucumber flavour. As it is evident from Fig. 3, acid content decreased gradually with the extension of

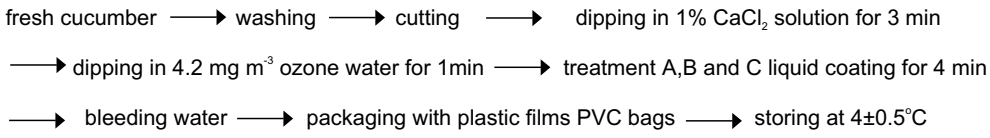

Fig. 1. The procedure for shelf-life extension tests of cucumbers.

T a b l e 1. Effects of different treatments on the weight loss

Treatment	Storage time (days)				
	2	4	6	8	10
A treatment	0.2138	0.5141	1.2151	1.5639	3.3154
B treatment	0.2069	0.5103	1.2150	1.8821	3.3568
C treatment	0.2003	0.5100	1.2143	1.4659	1.8467
C.K	0.2132	0.6136	1.2231	2.2821	4.5699
C.K'	1.2589	7.4256	15.5893	27.2455	31.2558

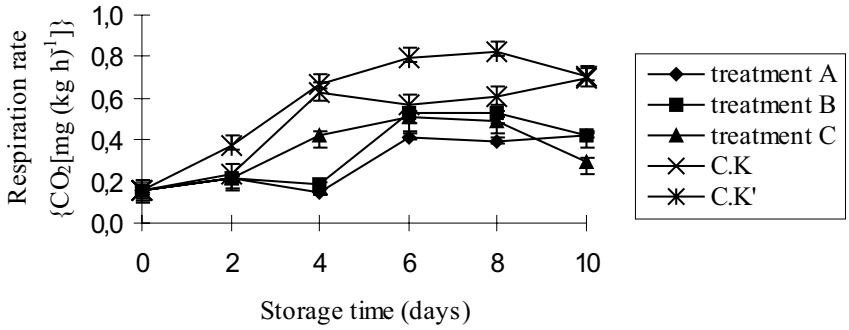

Fig. 2. Effects of different treatments on the respiration of minimally processed cucumber.

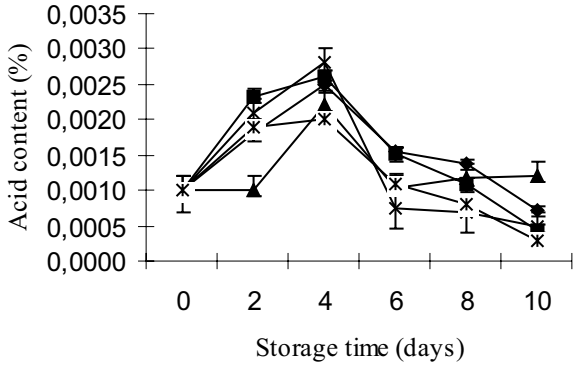

Fig. 3. Effects of different treatments on the acidity of minimally processed cucumber. Abbreviation as in Fig. 2.

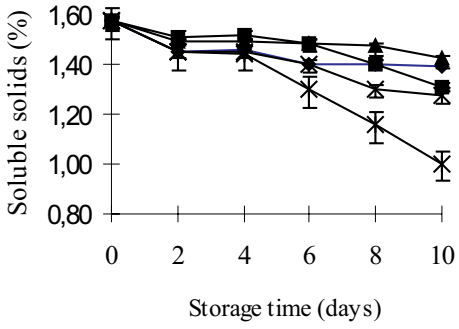

Fig. 4. Effects of different treatments on the soluble sugar of MP cucumber. Abbreviation as in Fig. 2.

storage time. Consequently, the quality of cucumbers degraded. The change in acid content was relatively higher in C.K' and the highest in C.K (see Fig. 3). After ten days storage, the acid content of treatment C was the highest, which shows that coating with treatment C could effectively contribute to the flavour retention.

Soluble sugar content

As soluble sugar is the principal sugar in cucumber, differences between treatments were noticed mainly in this sugar. The change in the soluble solids in cucumbers during storage periods is shown in Fig. 4. Due to the gradual maturing of cucumbers, the content of soluble solids rises during the first two days, decreasing thereafter. From the figure, it can be seen that the amount of change in treatment C soluble sugar is the smallest, keeping at the level of about 1.45%.

Vitamin C content

Cucumber is rich in vitamins, especially vitamin C (Vc). Vc is responsible for maintaining human physiological functions. Therefore, the preservation of Vc in cucumbers is very important. The results are shown in Fig. 5.

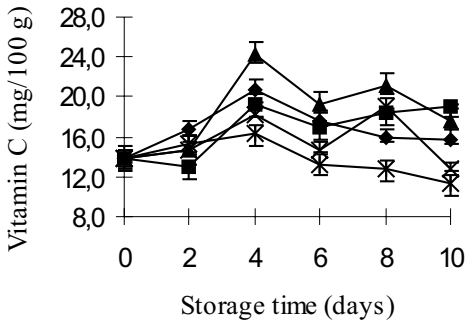

Fig. 5. Effects of different treatments on the vitamin C content of MP cucumber. Abbreviation as in Fig. 2.

From the figure, it can be seen that the Vc content increased during the second two days, caused probably by the cucumber maturing; then it subsequently decreased. Contrasting with C.K and C.K', the changes in the content of Vc in treatments A, B and C were obviously smaller, which shows that all three treatments could inhibit the decrease in Vc.

Chlorophyll content

The green in advanced plants is mainly due to with chlorophyll from chloroplast, which includes chlorophyll a and b. 'Chlorophyll-a' is responsible for the blue-green colour, while 'chlorophyll-b' is responsible for the yellow-green colour. Colour is the most important pointer to the freshness of vegetables. From Fig. 6, it can be seen that the content of 'chlorophyll-a' constantly decreases, while that of 'chlorophyll-b' increases. The total chlorophyll content decreased. To keep cucumbers fresh, the decrease in 'chlorophyll-a' must be retarded and 'chlorophyll-b' must be increased. In addition, the results show that the effects of treatment C are the best treatments of all.

Activity of PPO

PPO (polyphenol oxidases) and peroxidases exists in many advanced plants, catalyzing two different reactions: i) monophenol hydroxylation, which generates corresponding ortho-dihydroxide radical compounds; ii) ortho-diphenol oxidation, which generates ortho-diquinone. The ortho-iquinone continues changing, which results in the brownness being generated. Thus, the enzymatic action of PPO seriously affects the quality of the food appearance. The results in Fig. 7 show that the activity of PPO decreased slightly during the first four days, increasing rapidly thereafter. From the figure, the results of treatment A, B and C were obviously better than those of C.K and C.K'.

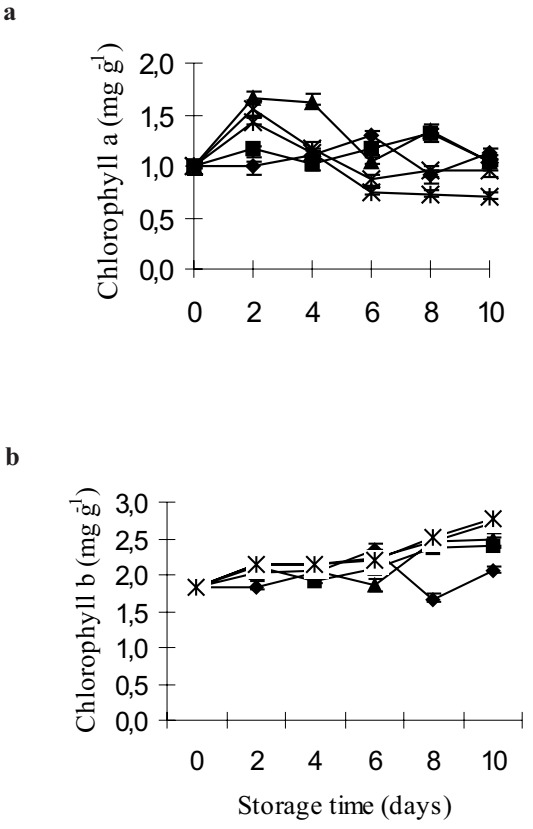

Fig. 6. Effects of different treatments on contents of chlorophyll a (a) and chlorophyll b (b) of MP cucumber. Abbreviation as in Fig. 2.

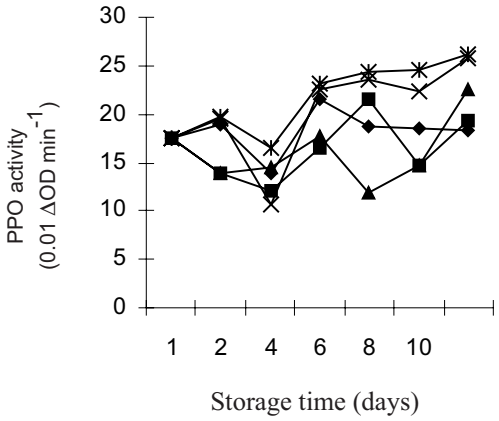

Fig. 7. Effects of different treatments on PPO activity of minimally processed cucumber. Abbreviation as in Fig. 2.

T a b l e 2. Organoleptic analysis of minimally processed cucumber during storage periods

Treatment number		Storage time (days)				
		2	4	6	8	10
A	Colour	Almost the same	Almost the same	Slightly changed	Slightly changed	Slightly changed
	Taste	"	"	"	"	"
		"	"	"	"	"
B	Colour	"	"	"	"	"
	Taste	"	"	"	"	"
		"	"	"		
C	Colour	"	"	Almost the same	Almost the same	Almost the same
	Taste	"	"	"	"	Slightly changed
			"			
C.K	Colour	Slightly changed	Slightly changed	Slightly changed	Slightly changed	Changed
	Taste	Slightly changed, acdic	Almost changed	"	"	"
				"		
C.K'	Colour	Changed	Slightly changed	"	Changed	"
	Taste	Changed, some alcohol flavor	"		"	"

Organoleptic analysis

The organoleptic analysis of minimally processed cucumber during storage periods is as shown in Table 2. From the table, it is found that storage time of MP cucumbers can be extended to 4~6 days by treatment C which obviously inhibits respiration and retards weight loss with a decrease in acid.

CONCLUSIONS

1. Through the tests, it was found that a concentration of 4.2 mg m^{-3} or so had a better effect on MP cucumbers.

2. The storage time of MP cucumbers can be extended to 4~6 days by treatment C which obviously inhibits respiration and retards weight loss with a decrease in acid.

3. The low cost and desirable effects of edible coating are of substantial benefit to the MP cucumber. At the same time, all of the substances selected in this study were permissible under the Chinese Food Additives Regulations (GB 2760-86), and were also suitable for HACCP. Edible coating has therefore very promising application.

ACKNOWLEDGMENT

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