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Effects of Package Environment on Keeping Quality during Storage in Cabbage and Broccoli

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Cabbage와 Broccoli의 저장중 품질유지에 미치는 포장환경의 영향

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Abstract

Effects on keeping quality according to the different package environment in cabbage and broccoli were studied. Opened 2 mil LDPE(low density polyethylene), sealed 4 mil LDPE and BA(barrier polyethylene) were used as package films. Weight loss was markedly in opened 2 mil LDPE in cabbage and broccoli as 6 and 28%, respectively. Carbon dioxide was higher in seal-packaging cabbage and broccoli with BA than in those with LDPE, and carbon dioxide content in the internal atmosphere of the sealed broccoli or cabbage with BA held at 4℃ was above 15 and 31% within 15 days, respectively, while oxygen content was depleted to 2% or less after 10 days. The main difference between volatile sulfur-containing compounds produced from cabbage and broccoli were the relative quantities and rates of production of hydrogen sulfide, carbonyl sulfide, methanethiol and dimethyl disulfide in opened 2 mil LDPE, sealed 4 mil LDPE and barrier bags during storage.

Key words : cabbage, broccoli, package, quality, volatile sulfides

Introduction

Vegetables such as cabbage and broccoli for sale during the winter traditionally has been stored in air ventilated structures. The usual prospect from these storages is the well known bleached head with parchment-like tissue and bland flavor. The use of mechanical refrigeration that maintains low temperature, however, greatly improves the quality and reduces the trimming losses(1). Parsons(2) observed that cabbage stored at 32°F in non-ventilated polyethylene crate liners in which carbon dioxide increased to 12.2% and oxygen was reduced to 4.9% retained its green color for 8 weeks while cabbage stored in perforated liners retained its color for 4 weeks only. But a good package should aid protection of products from physical, physiological, and pathological deterioration throughout marketing(3,4). Protection of procedure from mechanical damage is one advantage of consumer packaging. Packages such a over wrapped trays, which protect tomatoes and softs fruits from rough handling, will reduce bruising and other

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damage(5,6). Contamination by insects, dirt and customer handling is prevented Perhaps the main advantage of film packaging in maintaining quality is that evaporation of moisture is reduced: fresh appearance is maintained longer than for bulk produce. Waste and spoilage losses from shrivelling and weight loss are reduced(7,8) In some instances, beneficial modified atmospheres of increased carbon dioxide and low oxygen develop within packages and help retard aging(9-11). Sapers et al(12) described that hydrogen peroxide treatment on fresh-cut fruits and vegetables was more effective for their keeping quality. Many factors, however, cause problems in successfully using films to create controlled-atmosphere conditions during marketing. In this studies, different storage conditions were prepared and checked some general flavor quality such as the changes of weight loss, sensory analysis of appearance quality, respiration rates and volatile sulfur containing compounds in cabbage and broccoli during storage.

Materials and Methods

Materials

Cabbage(*Brassica oleracea* capitata L.) and broccoli (*Brassica oleracea* var. italica) used in these studies were purchased from the local market. Packaging and storage conditions with in each replicate, 36 uniform heads of cabbage and florets and stems of broccoli were separated into 6 groups, and the 2 samples were stored in opened 2 mil low density polyethylene bags(2 mil LDPE, 30 x 40 cm) at 4℃ for 50 days. During this time, headspace was used periodically for the experiment of oxygen, carbon dioxide and sulfur-containing volatiles.

Oxygen and Carbon Dioxide Analysis

Samples of the atmosphere inside the sealed 4 mil polyethylene and barrier bags were taken periodically after the polyethylene and barrier bags were sealed. The samples were analyzed for oxygen and carbon dioxide composition using a gas chromatograph with the thermal conductivity detector. Samples were injected into a 1.9 m x 4 mm(i.d.) CTR I column(Altech Associates Inc.) with a helium carrier flow of 50 mL/min The oven temperature was 50℃, and the injector and detector were healed at 70℃.

Static Headspace Analysis

The samples of analysis of sulfur-containing volatiles were prepared by blending 35 g inner or outer leaves of cabbage and florets or stems of broccoli(ca. 2 cm long) with 70 mL distilled water in a waring blendor(30s) to which was added internal standard (carbon sulfide). Samples were placed in a 125 mL Erlenmeyer flask with a glass arm and stopcock, and then set in an incubator at 30℃ for 30min. A gas sample syringe was inserted through the rubber septum and pumped in and out 9 times and a 3 mL sample was withdrawn for immediate injection(13). Sulfur-containing volatile compounds that accumulated in the headspace of the Erlenmeyer flask were analyzed periodically for 50 days using a Tracor MT-220 gas chromatograph(Micro Tek Instruments Corp. Austin, TX) equipped with dual channel electrometers and a Melpar flame photometric detector(FPD) combined with a flame ionization detector(FID) was used The effluent stream from the column was detected simultaneously by the FPD and FID. An omniscribe dual pen strip chart recorder(Model B-5218-5, Houston Instruments, Austin, TX) recorded output from each the FPD and FID detectors. A 1.8 m x 4 mm(i.d.) glass column packed with 40/60 mesh Carbopack BHT-100(Supelco, INC. Bellefonte, PA) was used. The column temperature was programmed from 60℃ to 130℃ at a rate of 25℃/min. Injection port and detector temperature were 140℃. High purity nitrogen carrier gas a flow rate of 40 mL/min was passed through an Alltech gas purifier(Deerfield, IL) before entering the column. For the FID/FPD flame, hydrogen of 126 mL/min and air of 53 mL/min were used Peaks were identified by comparing retention times with that of known standards.

Results and Discussion

Weight loss

Open-packaging of broccoli in 2 mil LDPE(low density polyethylene) film marked by reduced the loss of weight during 50 days storage. Seal-packaging of cabbage or broccoli in 4 mil LDPE and BA(barrier polyethylene) was less than 1%, the loss in weight and

2%, respectively, while reduction of weight loss in cabbage and broccoli open-packaging in 2 mil LDPE was 6 and 28%, respectively. About the similar reduction was marked with other vegetables seal-packaged with LDPE and BA, while the reduction was marked with other vegetables open packaged with LDPE(Table 1) Cabbage and broccoli that qualities of appearance were checked by sensory analysis during storage(Table 2). Fernandez et al(10) reported that ethanol and acetaldehyde accumulated to levels with the varieties of films effects on peach maturity stages.

Table 1. Changes in weight of cabbage and broccoli stored in opened 2 mil low density polyethylene bags(OLDPE), sealed 4 mil low density polyethylene bags(SLDPE) and barrier polyethylene bags(BA)

(unit : %)

Samples	Package conditions	Storage time(day) 10	20	30	40	50
Cabbage	OLDPE	98 21	93 68	93.26	93.19	93.15
	SLDPE	99 79	99 68	99.53	99.37	99.21
	BA	99.74	99.66	99.52	99 36	99.18
Broccoli	OLDPE	93.86	87.81	86 63	83 64	71 75
	SLDPE	99 38	98 71	98 59	98.49	98 25
	BA	99.20	98.41	98 23	98.02	96.75

Table 2. Changes in quality of cabbage and broccoli with sensory analysis during storage

Varieties	Quality	10 A	10 B	10 C	20 A	20 B	20 C	30 A	30 B	30 C	40 A	40 B	40 C	50 A	50 B	50 C
Cabbage	Wilt	-[a]	-	-	+[b]	-	-	+	-	-	++[c]	+	-	++	+	+
	Spoil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Undesirable smell	-	-	-	-	-	+	-	-	+	-	+	++	-	+	++
Broccoli	Wilt	-	-	-	+	+	-	++	-	-	++	+	-	++	+	-
	Spoil	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
	Undesirable smell	-	-	-	-	-	+	-	+	++	-	+	++	-	+	++

A means the condition that samples were stored in opened 2 mil low density polyethylene bags(OLDPE) B means that sealed 4 mil low density polyethylene bags(SLDPE), and C means barrier polyethylene bags(BA).
a means no changed, b means changed, and c means changed much in appearance and quality.

Oxygen and Carbon Dioxide Levels

Sealing of cabbage or broccoli in LDPE and BA was widely different permeability to oxygen and carbon dioxide(Table 3). Oxygen and carbon dioxide concentration increased greatly in LDPE and BA vegetables during storage, and the oxygen concentration dropped rapidly within 3 days. Respiration rates of broccoli were more than those of cabbage, and the rate of carbon dioxide accumulation in the vegetables was more than the corresponding rate of oxygen depletion Carbon dioxide was higher in seal-packaging vegetables with BA than in those with LDPE, and carbon dioxide content in the internal atmosphere of the sealed broccoli or cabbage with BA held at 4℃ was above 15 and 31% within 15 days, respectively, while oxygen content was depleted to 2% or less after 10 days. Usually films are much more permeable to carbon dioxide than to oxygen, so the rate of carbon dioxide accumulation is less than the corresponding rate of oxygen depletion. Polyethylene, although quite permeable, is usually not suitable for use as a sealed package. To avoid possible injury from accumulated carbon dioxide, too low oxygen or possible off-odors and off-flavors, it is recommended that films be perforated. In the tight package all the free oxygen is used in a short time, respiration becomes anaerobic and then carbon dioxide are produced. Films that have gas permeabilities of films effect on quality of peaches in modified atmosphere packaging(10). And McLachlan et al(11) reported, respiration rates of vegetables were measured over 4 day period and effects of temperature and preparation techniques were determined quantitatively in modified atmosphere packaging with film that oxygen permeabilities claimed by the manufactures ranged from(mL/m-2/day/atm) 3,000 for LDPE to 20,000~30,000 for plasticized PVC at 25℃.

Table 3. Headspace composition(carbon dioxide and oxygen) of cabbage and broccoli stored in sealed 4 mil low density polyethylene bags (SLDPE) and barrier polyethylene bags(BA)

(unit : %)

Package conditions	Varieties of gas	1	2	3	6	10	15	20	25	30	35	40	45	50
Cabbage SLDPE	Carbon dioxide	1.55	2.02	2.42	6.15	8.97	10.03	12.82	14.74	16.14	18.24	18.34	14.80	13.87
	Oxygen	21.22	19.04	18.66	11.36	9.54	7.67	6.47	3.90	1.45	1.30	1.59	2.51	6.75
BA	Carbon dioxide	1.97	3.84	4.65	9.12	15.37	24.24	29.91	35.89	48.75	49.06	49.10	36.40	35.55
	Oxygen	20.34	16.77	12.78	6.33	1.73	1.57	1.33	0.90	1.24	1.57	1.66	1.99	2.35
Broccoli SLDPE	Carbon dioxide	3.09	8.98	1.75	19.41	25.44	28.22	25.61	20.49	9.28	5.57	5.30	4.79	4.14
	Oxygen	14.28	10.14	9.42	2.67	1.63	1.43	2.01	2.76	11.81	16.33	17.70	18.27	18.49
BA	Carbon dioxide	4.49	10.66	15.27	25.72	31.82	39.09	43.95	47.83	54.04	57.87	45.22	29.55	28.42
	Oxygen	11.66	8.27	6.67	1.50	1.16	1.09	0.86	1.18	1.66	1.82	1.92	1.94	2.13

Table 4. Changes in volatile sulfides of cabbage stored in opened 2 mil low density polyethylene bags(OLDPE), sealed 4 mil low density polyethylene bags(SLDPE) and barrier polyethylene bags(BA)

(unit : ppm)

Package condition	Sample	Storage time(day)	Sulfur compounds			
			Hydrogen sulfide	Carbonyl dulfide	Methanethiol	Dimethyl disulfide
OLDPE	Inner	0	0,078	5 275	T	0 074
		10	0,116	5 338	T	0,829
		20	0 029	5 347	T	1,467
		30	0,018	5 607	0,608	5,224
		40	0,064	5 307	1 352	7,279
		50	0,372	4 624	1,460	13 616
	Outer	10	0,029	5 715	0.370	0,095
		20	0 028	4 223	0,334	1,025
		30	0,025	3 775	0 687	1,624
		40	0 045	3 768	1,554	1,808
		50	0,042	1 609	1,767	1,159
SLDPE	Inner	10	0 008	0 622	T	0 652
		20	0,016	0 172	T	0,134
		30	0,039	1 854	T	1.627
		40	0 570	2.451	T	4 796
		50	0,065	0 952	0.108	5,317
	Outer	10	0 057	0.307	ND	0 624
		20	0 476	0 156	ND	0 089
		30	0.567	1,701	ND	0,737
		40	0.637	2 495	0.105	2,224
		50	0 235	0,435	T	2,022
BA	Inner	10	0 053	0,370	ND	0,524
		20	0 039	3,795	ND	0,732
		30	0,385	4 027	ND	2,557
		40	0,157	4 524	T	3,781
		50	1 233	7 260	0,173	3,096
	Outer	10	0 036	0 409	0,099	0 493
		20	0 023	4 652	T	0 630
		30	0,229	4 224	0,455	1 499
		40	0 034	3,801	0 134	3,718
		50	0 238	2,259	0 039	3 262

T means trace below 0 010 ppm ND means not detected

Table 5. Changes in volatile sulfides of broccoli stored in opened 2 mil low density polyethylene bags(OLDPE), sealed 4 mil low density polyethylene bags(SLDPE) and barrier polyethylene bags(BA)

(unit : ppm)

Package condition	Sample	Storage time(day)	Sulfur compounds			
			Hydrogen sulfide	Carbonyl dulfide	Methanethiol	Dimethyl disulfide
OLDPE	Floret	0	0 235	1 401	0.290	0,424
		10	0,690	1 690	0.281	0 647
		20	0,902	2 395	0 305	1 651
		30	0 959	2 454	0,424	6,442
		40	0,827	3 242	0,523	11,652
		50	0,991	5 581	0 994	15 007
	Stem	0	0 124	0 831	T	0 106
		10	0,403	1 961	T	0,237
		20	0,680	2 161	0 030	1 244
		30	0,546	2,489	T	2,006
		40	0 445	3 480	T	2,665
		50	0 437	3 491	0,846	2,471
SLDPE	Floret	10	0 224	1 032	1,037	0,509
		20	0 527	2 401	0,331	1,213
		30	0,624	2 469	T	2,190
		40	0,613	2 579	T	7,612
		50	0 616	2 824	0 593	12,002
	Stem	10	0,549	0,630	0 147	0 442
		20	0,394	0,802	T	1,227
		30	0 484	1 320	T	1 362
		40	0,488	1 770	T	1,434
		50	0 353	1,781	0,033	2 537
BA	Floret	10	0,565	0 098	0,167	2 987
		20	0,537	0,371	0,513	5,319
		30	0 567	0,359	0 067	8 541
		40	0 498	0,278	T	10 611
		50	0,442	0,241	T	9,625
	Stem	10	0,216	0 034	ND	0,147
		20	0,198	0,221	T	1,176
		30	0 201	0,753	T	2 620
		40	0 232	0,688	T	2 755
		50	0,297	0 577	T	3 625

T means trace below 0,010 ppm ND means not detected

Volatile Sulfur-Containing Compounds

The sample(1 mL) of the atmosphere inside the sealed 4 mil LDPE and barrier bags containing cabbage and broccoli were taken periodically during storage at 4℃, and the samples were analyzed for volatile compounds using gas chromatography. Gas chromatograms of volatile sulfur-containing compounds in the internal atmosphere of sealed cabbage and broccoli with barrier bags during 10 days storage were tested. Four volatiles were detected and their identities conformed by comparison with the retention times of known volatile compounds and by mass spectrometry. The amounts of the volatiles in cabbage and broccoli were contained dimethyl disulfide and carbonyl sulfide more than others, and those volatiles were higher in broccoli than in cabbage. The volatiles of cabbage and broccoli were collected by the static headspace method using 125 mL Erlenmeyer flask with glass arm and stopcock, and determined by gas chromatography. Table 4 and 5 show some results of gas chromatographic analyses of sulfur-containing volatiles, low boiling compounds in cabbage and broccoli during storage. A considerable difference was observed among the samples in the amounts of the sulfur-containing compounds. The main difference between volatile sulfides produced from cabbage and broccoli were the relative quantities and rates of production of hydrogen sulfide, carbonyl sulfide, methanethiol and dimethyl disulfide in opened 2 mil LDPE, sealed 4 mil LDPE and barrier bags. The most striking difference was in the concentration of dimethyl disulfide according to storage period in opened 2 mil LDPE bags of the broccoli florets. The amounts of dimethyl disulfide in the broccoli florets 50 days after the broccoli was stored contained 15.007 ppm, approximately 35 times as much as in those behind storage. Dimethyl disulfide and carbonyl sulfide were found in significant concentration in the samples, but hydrogen sulfide and methanethiol were notably absent or insignificant. Ron et. al(14) reported that volatile oil of cabbage contained 15 varieties of sulfides and mercaptans with hydrogen sulfide, methanethiol, carbon disulfide and dimethyl disulfide. And Charles et. al(15) described also, methanethiol was lower concentration, but dimethyl disulfide was most of sulfur- containing volatile compounds in broccoli under anaerobic conditions, and the result was similar pattern of ours.

요 약

Cabbage와 broccoli의 저장 중 포장환경에 따른 품질변화에 대하여 실험하였다. 포장 필름으로 opened 2 mil LDPE(low density polyethylene), sealed 4 mil LDPE 및 BA(barrier polyethylene)을 사용하였다. 중량 감소는 opened 2 mil LDPE에서 가장 많았는데, cabbage와 broccoli에서 각각 6%와 28% 이었다. 이산화탄소는 LDPE보다 BA로 seal 포장한 cabbage와 broccoli에서 많았으며, 그 함량은 15일에 4℃의 BA 포장에서 각각 15%와 31%이었으나, 산소 함량은 10일 후 약 2% 감소하였다. Cabbage와 broccoli의 휘발성 유황 함유화합물(hydrogen sulfide, carbonyl sulfide, methanethiol 및 dimethyl disulfide) 중 주요한 차이는 각각의 포장환경에 따른 상대적인 양과 생성율이었다.

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