PROTECTING PICKLING CUCUMBERS FROM DETERIORATION BY CONTROLLED ATMOSPHERES.

Ronald W. Buescher
Department of Food Science, University of Arkansas
Route 11, Fayetteville, AR 72703

Cucumber pickle products are manufactured from fermented-brine cured or fresh cucumbers. Fermentation allows the cucumber pickles to be bulk stored in brine without deterioration for several months. However, brine cured pickles are not suitable for manufacturing fresh pack products since internal tissues become transluscent and fresh cucumber flavors are altered during brining. Since only fresh cucumbers can be utilized for fresh pack products, processing has to be intensive during the summer production season or cucumbers need to be transported from remote southern areas including Mexico to fulfill market demand. Methods of storage that protect against deterioration for two or more weeks would allow processors to extend the utilization of local production, to moderate fluctuations in supply and to accumulate specific fruit sizes.

Most recommendations for storage of cucumbers have developed from studies on slicing (fresh market) cultivars (Apeland, 1961; Isenburg, 1979; Kader and Morris, 1977; Lutz and Hardenburg, 1977). Studies on pickling cucumbers have mainly focused on the benefits of precooling, disinfestants, and protecting against water loss and exposure to ethylene for retarding deterioration during postharvest handling (Cook and Plug, 1960; Costilow et al., 1984; Hood, 1967; Lee et al., 1982; McCombs and Winstead, 1963; Poenicke et al., 1977). Esselen and Anderson (1956) observed that holding pickling cucumbers for more than three days at 21-27° or 1.7°C caused soft texture and off-flavors when processed as fresh pack spears. Etchells et al. (1973) reported that pickling cucumbers should be stored at 10°C and 95% R.H. Fellers and Plug (1967) examined the effects of temperature and controlled atmospheres (CA) on prolonging storage and maintaining fresh pack quality of three fruit sizes (no. 1, 2 and 3) of SMR-15 and SMR-58 cultivars. They concluded that (1) washing prior to storage enhanced deterioration (2) size no. 1 fruits were unacceptable after 3 days of storage (3) size no. 2 SMR-15 fruits could be stored for 2 weeks at 1.7°C in 5% O_2 and 5% CO_2 and (4) size no. 3 SMR-15 fruits could be stored for 3 weeks at 1.7°C in 5% O_2 and 5% CO_2 or 3% O_2 and 10% CO_2. If kept at low temperatures, chilling injury symptoms were not apparent. Storage was mainly limited by growth of decay organisms that initiated deterioration at the spine aperatures. Unfortunately control samples were held at 4.4°C in air rather than at 1.7°C, and 3% O_2 with 10% CO_2 was not used for size no. 2 fruits which makes formulating conclusions difficult.

The objectives of the research reported in this paper were to evaluate the effects of O_2, CO_2, SO_2 and temperature on prolonging storage of pickling cucumbers with acceptable processed quality characteristics.

METHODS AND MATERIALS

Size no. 3 (3.8-5.1 cm diameter) cucumbers were obtained from Atkins Pickle Co. (Atkins, AR) at the time of delivery and unloading. Most samples were determined to be "Carolina" although some were unidentified. Fruits were washed in a reel washer with tap water, air dried and placed in 8 L storage containers, equipped with gas inlet and exhaust ports. The containers were held in constant temperature chambers. Controlled atmospheres were created by mixing N_2, O_2 and CO_2 with air in the system described by Shaw and Kattan (1971). Gas concentrations were monitored with a Fisher-Hamilton gas partitioner. Treatments with SO_2 consisted of exposing cooled fruits to 1% or 2% SO_2 for 30 min. them 0.25% or 0.5% for 30 min. at weekly intervals. The lower levels of SO_2 are used for prolonging storage of grapes (Lutz and Hardenburg, 1977).

Triplicate samples were used for each treatment. Some of the treatments were repeated on cucumbers held in 20 L and 200 L containers to observe the response of CA on larger quantities of fruit.

After storage the cucumbers were evaluated for defects detrimental to processing quality and flavor characteristics, then washed and processed as fresh pack kosher spears, using simulated commercial procedures and ingredients. Primarily, decay that penetrated epidermal tissues caused fruits to be unacceptable for processing. Cucumbers processed without being stored served as the control treatment.

RESULTS AND DISCUSSIONS

Effects of O_2 concentration:

Reducing O_2 levels to 5% or less reduced deterioration during storage at 4°C (Table 1). Cucumbers held in 0.5 to 3% O_2 were free of decay for 2 weeks while decay was present on several of the fruits held in higher O_2 atmospheres. Low O_2 levels were not suitable for protecting against deterioration for more than 2 weeks. Cucumbers in 0.5% O_2 were unacceptable when sampled from storage at 3 weeks due to water-soaking of mesocarp tissue beneath the epidermal layers. Quality of all samples processed after storage for 2 weeks was acceptable. After 3 weeks slight off-flavors were noted in all treatments.

Table 1. Effect of O_2 Concentration on Retarding Deterioration of Pickling Cucumbers During Storage at 4°C.

O_2 (%)	Percent Unacceptable Weeks in storage 1	2	3	4
Air	5	32	80	100
15	8	24	83	100
10	8	30	77	100
5	0	10	38	100
3	0	0	31	100
2	0	2	35	97
1	0	0	24	100
0.5	0	0	58	100

Effects of CO_2 concentration:

Elevated levels of CO_2 prevented deterioration of pickling cucumbers (Table 2). Concentrations above 15% were effective in protecting against decay or other visible defects for 5 weeks at 4°C. Symptoms of chilling or CO_2 injury were not apparent although fruits deteriorated when they were transferred to air at 22°C for 48 hours. Samples processed after 1, 2, 3 and 4 weeks of storage in 15 to 40% CO_2 had good appearance and texture. After 3 weeks of storage some off-flavors were detected, and after 4 weeks of storage, flavor of the processed samples was unacceptable.

Table 2. Effect of CO_2 Concentration on Retarding Deterioration of Pickling Cucumbers During Storage at 4°C.

CO_2 (%)	Percent Unacceptable Weeks in storage 1	2	3	4	5
Air	6	36	84	100	100
5	10	34	81	100	100
10	8	24	67	92	100
15	0	0	6	13	20
20	0	0	2	0	4
30	0	0	0	0	0
40	0	0	0	2	0

Combination of elevated CO_2 and reduced O_2:

Deterioration of pickling cucumbers was prevented for 1 week in air, 2 weeks in 5% or 10% CO_2 with 3% O_2, 3 weeks in 15% CO_2 with 3% O_2 and 5 weeks in 20% or 30% CO_2 with 3% O_2 (Table 3).

Reducing the O_2 level to 3% assisted in reducing deterioration when CO_2 concentrations were 15% or lower, but with 20 and 30% CO_2, deterioration was prevented regardless of O_2 concentration (Tables 2 and 3). Although off-flavors were detected in all samples processed after 3 weeks of storage, they were less intense when 3% O_2 was used in combination with elevated CO_2 than when only elevated CO_2 was used.

Table 3. Effect of Elevated CO_2 and Reduced O_2 Atmospheres on Retarding Deterioration of Pickling Cucumbers During Storage at 4°C.

		Percent Unacceptable				
CO_2	O_2	Weeks in storage				
(%)	(%)	1	2	3	4	5
Air	Air	0	26	73	100	100
5	3	3	0	0	25	81
10	3	0	0	4	28	70
15	3	0	0	0	8	18
20	3	0	0	0	0	0
30	3	0	0	0	0	0

Effect of temperature:

A study was conducted to examine the effects of storage temperature on cucumbers held in air or 20% CO_2 with 3% O_2 (Table 4). In air, fruits were free from defects when sampled at 1 week in storage at 1°C, but with increasing temperature and time in storage, deterioration increased. In 20% CO_2 with 3% O_2, deterioration was prevented for 2 weeks at 1, 4 and 10°C. At 1° and 4°C acceptable quality was maintained for 4 weeks, the duration of the experiment, but at 10°C quality deteriorated after 2 weeks in CA storage. At 15 and 20°C deterioration was obvious regardless of storage atmosphere although the CA tended to reduce the amount of unacceptable fruit.

Table 4. Effect of Temperature on Deterioration of Pickling Cucumbers Held in Air or Elevated CO_2 and Reduced O_2 Atmosphere.

	Percent Unacceptable							
	Weeks in storage atmosphere							
	Air				20% CO_2, 3% O_2			
°C	1	2	3	4	1	2	3	4
1	0	13	40	83	0	0	0	0
4	4	28	77	100	0	0	0	0
10	14	80	95	100	0	0	22	58
15	20	86	100	100	10	35	80	96
20	57	100	100	100	23	64	100	100

Effect of intermittent SO_2:

Intermittent exposures to SO_2 were effective in prolonging storage of pickling cucumbers (Table 5). Defects were prevented for 30 days when cucumbers were held in air and exposed to the 2 x SO_2 treatment or when held in 3% O_2 and exposed to either the lower or higher levels of SO_2. Spears processed from the stored cucumbers had acceptable appearance but off-flavors similar to those observed from the elevated CO_2 treatments were detected. Surprisingly, bleaching of chlorophyll or water-soaking was not caused by exposure to SO_2. Thus, intermittent SO_2 provides an alternative to elevated CO_2 for preventing deterioration and it should assist with determining physiological changes caused by storage time, temperature and CA.

Table 5. Effect of Intermittent SO_2 on Retarding Deterioration of Pickling Cucumbers during Storage at 4°C.

Storage Treatment[z]	Percent Unacceptable after Storage for 30 Days
Air	100
3% O_2	95
Air + SO_2	38
3% O_2 + SO_2	0
Air + 2 x SO_2	0
3% O_2 + 2 x SO_2	0

[z] Cucumbers were exposed to 1% SO_2 for 30 min. immediately after cooling and then 0.25% SO_2 for 30 min. at weekly intervals. The 2 x SO_2 treatment consisted of twice the SO_2 concentration indicated for the SO_2 treatment.

Effect of CA and SO_2 on flavor:

A study was designed to focus on the effects of the best storage treatments on the development of off-flavors in fresh and processed products (Table 6). Slight off-flavors were detected in fresh tissues from cucumbers stored for 3 and 4 weeks regardless of storage atmosphere. After processing,the degree (severity) of off-flavors was enhanced. Storage in reduced O_2 (3%) tended to ameliorate the degree of off-flavors observed after processing. The off-flavors were most concentrated in the epidermal tissues which would be expected to contain the highest level of lipid components.

Effect of Storage Treatment on Flavor of Cucumbers and Their Processed Product.

Storage Treatment (4°C)	Degree of Off-Flavor[z]					
	Weeks in storage					
	Fresh			Processed		
	2	3	4	2	3	4
Air	0	1.4	--	0	2.7	--
20% CO_2, ambient O_2	0	1.3	2.2	0	3.0	7.4
20% CO_2, 3% O_2	0	0.8	1.4	0	2.3	4.8
Air + 2 X SO_2	0	2.6	2.0	0	2.8	6.1
3% O_2 + SO_2	0	1.5	1.7	0	2.8	4.5
LSD, 5%	--	NS	NS	--	NS	1.1

[z] Off-flavor was determined by 14 sensory panelists on a scale of 0 to 9 with 0 representing no off-flavor and 9 representing extreme off-flavor. Samples from nonstored cucumbers were used as a reference by the panelists.

CONCLUSIONS

1. Storage-life of pickling cucumbers was limited by decay that was controlled by storage at low temperatures in elevated CO_2 atmosphere or with intermittent exposure to SO_2.

2. Symptoms of chilling injury, browning, yellowing, water-soaking or development of other physiological disorders were not apparent while cucumbers were held in storage.

3. Flavor quality deteriorated during storage. Processing of stored fruits accentuated the degree of off-flavors. Although decay was controlled for several weeks by CA or SO_2, storage should be restricted to 2 weeks or less until procedures are developed to prevent off-flavors in the processed products.

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