Pak J Sci Ind Res 2002 ***45*** *(4) 259-261*

POST HARVEST PRESERVATION OF FRUITS AND VEGETABLES; STUDY ON CARROTS PRESERVED BY MODIFIED ATMOSPHERE PACKAGING (MAP) TECHNOLOGY

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(Received 1 November 1999; accepted 05 September 2001)

The objective of this study is to note the results of modified Atmosphere Packaging (MAP) Technology for post harvest preservation of carrots (*Daucus carrota L.*). It was observed that peeling treatment, film type and days of storage had a significant effect on CO_2 and O_2 percentages within bags of carrots stored at 7°C. The bags with peeled carrots contained significantly less CO_2, 9.4% and more O_2, 16.1% than non-peeled carrots, 17.6% CO_2 and 14.3% O_2 during the 28 day storage period.

Key words: Post harvest preservation, Carrots, Modified atmosphere packaging.

Introduction

Primarily, the carrots were used for medicinal purposes and were not consumed as a plant source for food until the early twentieth century. Carrots are now one of the major crops and are consumed in many forms. It is an excellent source of vitamin A and a good source of vitamins B_1, C, and B_2. It contains 16.9mg of carotene, which can be converted to retinol by humans (Wills *et al* 1989).

It has been observed that processing of fresh produce by heating or freezing may destroy cellular structure and reduce the turgor pressure (Bourne 1989). Consumers desire firm, crisp and juicy texture in raw vegetable. Firmness of fruits and vegetables is a basic textural property.

Vegetables, bulbs, roots and tubers have storage organs that contain food reserves utilized upon the plants resumed growth. However, these reserves are often held to be consumed during propagation. Upon harvest, the metabolic rate of these plants is low and under appropriate storage conditions dormancy can be prolonged (Wills *et al* 1982)

As regards carotenoid, there are several factors, which affect the stability. Emodi (1978) and Stefanovich and Karel (1982) reported that carotenoid would be preserved by storing the products under vacuum or in an inert gas. The stability of β-carotene is also increased by increasing nitrogen levels in the atmosphere (Baloch *et al* 1977) Carotenoids, due to their highly unsaturated chemical structure, are sensitive to light and oxidation, therefore, the instability of the carotenoid content of plants, vegetables and fruits tends to decrease rapidly during processing and storage.

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Zagory and Kader (1988) suggested that appropriate temperature for storage of fruits and vegetables in flexible plastic films need to be determined. Also, little information is available on respiration rates as affected by different combination of O_2 and CO_2 concentrations. Furthermore, additional techniques are needed to make MAP a practical alternative to the economically less feasible CAP technology. King and Bolin, (1989) indicated that the challenge for future was the extension and expansion of current knowledge to include peeled, cut and otherwise partially processed fruits and vegetables.

The future prospects of integrating aseptic and modified atmosphere packaging have been discussed by Brody (1996). Mylene *et al* (1996) have studied the preservation of freshly prepared diced yellow onion by MAP.

In another work, Pretel *et al* (1998) stored the fresh oranges for 11 days at 4°C by using MAP technology. Modified atmosphere packaging of vegetables with high performance plastic films was also studied recently by Ichiji (1998) in Japan.

Respiration rate is an excellent indicator of metabolic activity of the tissue and is a useful guide to the potential storage life of produce. The rates of respiration of fruits and vegetable (measured as either O_2 consumed or CO_2 evolved during the course of its development, maturation, ripening and senescent period) have characteristic patterns.

The tolerance of fruits and vegetables to reduced O_2 and elevated CO_2 can be significant when determining the appropriate modified atmosphere for a cmmodity and when determining adequate aeration rates.

Successful storage of fresh produce requires a reduced rate of ripening, or a delay in the onset of ripening and prevention of decay so that "freshness" is maintained at a high level of acceptability to the consumer. Such storage is achieved through altering the environment of the produce immediately after harvesting by lowering temperature, by applying chemicals, by changing composition of atmosphere or by combination of these treatments.

The technology of controlled atmosphere and modified atmosphere packaging (CAP/MAP) has been successfully applied in European market for more than 25 years (Lioutas 1988) CAP is an expensive technology as compared to MAP where gaseous environment inside the package is intentionally altered and maintained through out the shelf life of the product. Whereas, in MAP, the gaseous environment surrounding the product changes during storage based upon film permeability and gas production or consumption by the food product.

The present study has been carried out using semi-cold storage conditions of the order of 7°C for fruits and vegetables.

In order to achieve a detailed study, carrots have been selected to determine physical and chemical changes stored at 7°C (45°F) under modified atmosphere.

Materials and Methods

Carrots packaging and storage. Carrots were sorted and 120 carrots were selected based upon uniformity of size, lack of physical damage and freedom from discolouration. These carrots were washed and free surface moisture was removed by air drying and wipening off moisture. One half of the carrots were hand peeled using a vegetable peeler.

Peeled and non-peeled carrots were randomly packed (three per bag) in four different plastic films bags. Three packaging polyethylene (PE) films and one polyvinylidene (PVDC) were obtained from three different commercial sources. The film No 1 was most permeable where as films No. 2 and 3 were almost similar but less permeable than film No. 1. Film No.4 was considered as barrier film, allowing no significant change in atmosphere after 24 h (Table 1). The bags were heat sealed with no adjustment of the atmosphere. These packed carrots were stored in the dark at 7°C (45°F) for 28 days.

Table 1

Relative permeabilities of four films to CO_2 and O_2 for 24h storage at 7°C

Films	CO_2 %		O_2%	
	0 h	24 h	0 h	24 h
01	2.77	0.24	19.55	21.05
02	21.58	0.70	8.67	20.97
03	23.76	2.61	7.49	19.77
04	52.36	51.65	1.79	1.69

Table 2

Mean CO_2 percentages of atmospheres in 4 films for carrots stored at 7°C for 28 days

No. of Days	Mean CO_2 %			
	Film No. 1	Film No.2	Film No.3	Film No.4
0	0.73	0.82	3.14	3.37
7	6.71	1.77	3.89	42.16
14	3.38	1.28	3.18	40.85
21	2.68	5.12	4.86	85.44
28	0.93	1.19	4.16	22.29

Table 3

Mean CO_2 percentages of atmospheres in 4 films for carrots stored at 7°C for 28 days

No. of Days	Mean CO_2 %			
	Film No. 1	Film No.2	Film No.3	Film No.4
0	21.48	20.88	19.05	18.47
7	18.95	17.98	13.42	4.18
14	20.38	19.52	12.69	7.07
21	20.50	18.99	11.20	6.08
28	21.34	20.14	14.03	11.05

Sample analysis. Sample bags of carrots were taken after 0 (fresh) 7,14,21 and 28 days of storage for analysis.

Estimation of O_2 and CO_2 The sample bags were analyzed for O_2 and CO_2 content. A strip of adhesive resealing plastic tape was placed onto the packaging film surface to allow for leak proof sampling of the headspace gas. A sample of the headspace gases (3 c c) was obtained by inserting a syringe needle (22 gauge) through the tape into the package and drawing a 3 c.c. sample. The sample was immediately injected into a gas chromatograph (G.C) for analysis.

The O_2 and CO_2 concentrations were determined by using 1.8 m, 0.625 mm i. d stainless steel CTRI column (Alltech Associates, Deerfield, 11.) The Hewlett Packard Model 5890 A gas chromatograph with T.C detector was used. One ml gas injection valve was flushed with 3cc of the package headspace gases prior to injection. Helium with flow rate of 50ml/min was used as a carrier gas. The column temperature was 70°C and detector temperature was kept at 90°C. The concentration of O_2 and CO_2 were determined as percentage of package headspace gases.

Standardization was carried out using known percentage of CO_2 and O_2 mixture. In both the gases the error was not more than ± 0.1%.

Results and Discussion

It was observed that peeling treatment, film type and days of storage had a significant effect on CO_2 and O_2 percentages with in bags of carrots stored at 7°C. The accumulation of CO_2 and loss of O_2 during storage was influenced by the type of film.

The result shows that the CO_2 and O_2 percentages did not vary significantly in films No 1 and 2 during 28 days storage period (Tables 2 and 3) therefore, these two films were permeable to CO_2 and O_2 at a rate that was equal or greater than the respiration rate of the carrots stored in these films. The CO_2 could move out of the bag and O_2 could move into the bag through the films. The CO_2 percentage was significantly higher for films No 3 and 4 on 21 day than on 0 day with film No. 3 containing 4.9% compared to 3.1% CO_2 and film No. 4 containing 85.4% compared to 3.4% (Table 2).

The CO_2 accumulation at 21 day was significantly higher than at 14 for film No.3,4.9% compared to 3.2% On no other occasion, the CO_2 percentage was significantly different from those at either day O or day 21 for film No. 3 and 4.

The O_2 percentage in film No. 4 significantly decreased between day 0 and 7 from 18.5% to 4.2%, but did not change during the remainder of storatge (Table 3). The O_2 percentage was not significantly different in film No.3 although it averaged 11.2% on day 21.Compared to 19.1% on day O. Irving (1984) reported a recommended maximum level of 4 to 5% CO_2 and a minimum 3 to 4% O_2 as a relative tolerance for respiration to occur. In this study, the CO_2 percentages reached an average of 42.2% by day 7 for film No.4. Respiration by carrots change from oxidative to fermentative if there is not enough O_2 or there is too much CO_2 surrounding the product. A fermentation aroma was detected for both peeled and non-peeled carrots packaged in film No. 4 after 21 days of storage. These results indicate that film No.4 traps an excessive amount of CO_2 and does not allow for replacement of an adequate amount of O_2, therefore, it is not suitable for extended storage.

Peeled carrots. The bags with peeled carrots contained significantly less CO_2, 9.4%, and more O_2, 16.1% than non-peeled carrots, 17.6% CO_2 and 14.3% O_2, during the 28 day storage period.

The results of studies on primary storage are indicative of the fact that it is feasible to exploit the advantages of natural ventilation for improvement of quality of stored fruits and vegetables with the help of appropriate technology. The application of developed cold store modernization technology may further result in saving the post harvest losses.

The technique will save energy required for bringing the cold storage temperature to below freezing.

Conclusion

Carrots packed in film No. 2 and 3 did not significantly vary from carrots packed in film No. 1. These three films maintained the CO_2 levels below maximum acceptable levels and O_2 percentages above minimum acceptable levels. Film No. 4, the barrier film, was not a desirable film to use as it increased CO_2 level in the atmosphere, increased fermentation aroma and increased slime on the surface. It was also observed that peeling of carrots further reduced CO_2 production and O_2 consumption.

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