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Storage of Cranberries in Plastic Packaging

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Abstract: The nowadays-great interest for cranberries has been reflected in the high demand for this fruit out of the traditional consuming season. This work presents a study of modified atmosphere packaging in order to extend the post harvest life of fresh cranberries. About 35 kg of fresh cranberries harvested by hand in two fields in the region of Québec, Canada were randomly packaged in bags of 200g. Four kinds of plastic films (Cryovac, Dartek by Dupont, and two types of commercially available plastic bags) were used. Both the Cryovac and the Dupont bags were vacuum-sealed. All packages were stored at 4°C. During 16 weeks the color, the pH, the Brix, the texture, the moisture content and the general appearance were monitored. The cranberries stored under anaerobic conditions revealed an increase of color intensity (anthocyanine content). These packages also showed cranberries with the lowest superficial color difference from the fresh cranberries, and a 30% less fruit rejection than the other cranberries. The texture tests demonstrated an initial tenderness for vacuum packaging that did not increase with storage time as experienced by the other packaging.

Key words: Cranberries, storage, plastic packaging

Introduction

Native to North America, the cranberry (*Vaccinium macrocarpon*, Ait) is an evergreen vine that, in the last decades, has strongly increased in production and consumption (Eck, 1991). The production in Canada raised from 1,342 hectare in 1991 to 2,616 in 1999, a 95% increase, with an estimated farm value of $55.5 millions a year. The province of Québec represents 18% of production area and 23% of industry in Canada. The experts based on the 900 hectare of land for the crop can predict a value of $20 million this year (Vandenberg and Parent, 1999). This interest is probably due to the high nutritional value, particularly in vitamin C content, of the fruit (Kuzminski, 1996).

Cranberries sales are approximately 90% with processed products, primarily juice with the remaining 10% sold as fresh fruits (Caruso, 1997).

The agriculture producers awarding of the increasing demand for fresh cranberries have to be aware of advance in technology in order to efficiently decrease the losses, which can be of 30-40% (Caruso and Ramsdell, 1995). It is possible to see fresh cranberries in the grocery stores a few months after harvest season (from September till late December with a peak in October for Thanksgiving in Canada). Traditionally cranberries are stored by common (air cooled) ventilated storage located near the bogs. At present refrigerated storage is often used (Hardenburg *et al.*, 1990). Under this treatment, cranberries are found to remain under marketable conditions for a period of 2-4 months.

Losses during refrigerated storage result from combination of physiological breakdown and fungal decay (Hardenburg *et al.*, 1990). Research indicates a relation between the spoilage and improper handling (Graham *et al.*, 1966 and Massey and Chase, 1981), use of fertilizers in vines (Swanson and Weck, 1975), the technique of harvest (water pick/ hand pick) (Ceponis and Stretch, 1983), storage in the chaff and kind of cultivars. Swanson and Weck (1975) affirm that Stevens cultivar was observed to have the greatest storage life.

Cooling is well known as the main post harvest technique to store fruits and vegetables in order to reduce the respiration rate of the product which is responsible for all metabolic activities. In line with this, Modified Atmosphere (MA) is another technique to control the respiration rate. Raising the CO_2 levels and reducing O_2 content of the microatmosphere around the commodities can suppress decay of fruit, retard senescence and delay softening, minimize enzymic activity and reduce respiration rate (Kader, 1989; Shamaila *et al.*, 1992 and Gunes *et al.*, 2002). The interest of MA started at the middle of last century with great results in apple storage. Nowadays it is common to Apply Modified Atmosphere Packaging (MAP). MAP is defined by Prince (1989) as "the initial alteration of the gaseous environment in the immediate vicinity of the product, permitting the packaged product interactions to naturally vary their immediate gaseous environment".

Recently the packaging of horticultural commodities in polymeric films with specific gas permeability in combination with low temperature storage has increased (Kader *et al.*, 1989) performing great beneficial effects. Although these techniques are considered expensive due to the cost of maintaining the conditions and installation (Batagurki *et al.*, 1995), extensions up to 25% in shelf life and beneficial aspects of branding and marketing have to be considered (Cocatas, 1991). Nevertheless MAP can produce all the positive and negative effects of any MA. Some of the positive aspects are, reducing water losses and reducing contamination by handling or by contact with infected products. On the other hand an incorrect atmosphere gas balance can lead to fruit injuries. It is also important to recognize that package has a lot of effects on fresh fruits. Packages are barriers to water vapor movement and can aid in the maintenance of high relative humidity (RH) and turgor of fruits. Maintenance of a very high RH can lead to moisture condensation on the commodity, creating conditions favorable for pathogen growth (Zagory and Kader, 1988).

Vacuum package respiring foods such as fresh fruits or vegetables continue to respire. In the respiration process, the small amount of O_2 present in the tissue of the product is consumed and CO_2 and moisture are produced. In a practical way, therefore, the vacuum packaging of respiring food becomes MAP (Brody, 1989). In some cases, levels below O_2 tolerance, lead to product increased anaerobic respiration and the development of off flavors due to accumulation of ethanol and acetaldehyde (Zagory and Kader, 1988; Gunes *et al.*, 2002).

Because of the increasing demand for cranberries up to the traditional (Thanksgiving and Christmas) consumption season this work presents a study of the post-harvest storage life of fresh cranberries. Product quality indicators were monitored such as color, pH, °Brix, texture, moisture content and general appearance of stored cranberries for 16 weeks, as influenced by the effect of different modified atmosphere conditions created by plastics films in cold storage.

Materials and Methods

Fruit: All cranberries (*Vaccinium macrocarpon*) used in this study were of the Stevens cultivar and hand picked on October 24th 2001 at a local farm. Upon harvest the fruit was placed in cold storage at 0°C. About 16 hours after harvest, the cranberries were weighed and packaged. All cranberries were placed in a cold room at 4°C. The control cranberries were not packaged and kept in bulk, open air cold stored. Every week a sample from each treatment combination was analyzed.

Packaging: The cranberries were randomly selected and packaged. Four kinds of plastic bags were used for this study. For the vacuum storage, film pouches (of 20x20cm) were prepared from a DuPont double layer film composed of nylon (Dartek N-201) and polyethylene (Sclairfilm A-322), and with a single layer high density polyethylene film (Cryovac, Canada). The other 2 pouches used were commercially available polyethylene freezer bags (Ziploc freezer bags and Ziploc Double guard freezer bags). Manufacturers specifications are presented in Table 2. A total of 192 (3 replicas* 4 kind of bags * 16 weeks) pouches were filled with about 200g of cranberries. For the vacuum packaging a Multivac vacuum packaging machine (Model A300/16) was used.

Quality Measurements: Colour: The color, texture, taste and aroma are the major factors during the selection and purchase of food (Lees, 1975). This makes color, one of the principal attributes used to evaluate the quality of food (Bourne, 1982). The attractive color of the cranberries is due to the high content of anthocyanin red pigment and yellow flavonoids (Francis and Clydesdale, 1975). Although the existence of studies establishing relationships between the surface color of cranberries and color of juice (Francis and Servadio, 1962) the relationships are not very precise so for this study both were analyzed. The surface color was measured by a Minolta Colorimeter (Model CR 300X). The coordinates, L*,a*,b* obtained provide information on lightness directly (CIE, 1978). Where L* coordinate is the lightness coefficient, it ranges from 0 (black) to 100 (white), the a* coordinate is the red-purple/blush-green (positive/negative value) and the b* coordinate is the yellow/blue color (positive/negative value) (McGuire, 1992). Hue angle (h°) and chroma (C*) an index somewhat analogous to color intensity were also calculated:

$$H^\circ = \tan^{-1} (b^*/a^*) \quad (1)$$
$$C^* = [(a^*)^2 + (b^*)^2]^{1/2} \quad (2)$$

The color difference (ΔE) was also calculated in order to evaluate the change in color between fresh and stored cranberries.

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \text{ with,} \quad (3)$$
$$\Delta L = L^* - L^*_t ; \quad (4)$$
$$\Delta a^* = a^* - a^*_t ; \quad (5)$$
$$\Delta b^* = b^* - b^*_t \quad (6)$$

where t indicates the target color, the coordinate of fresh fruit.
The colorimeter was initially calibrated on a Minolta starch white palette (L*98.28, a*-0.05 and b*2.32). For the surface color determination, 11 cranberries, randomly picked from each bag or control group, were measured and the average value was calculated.
The color of the juice was determined by a spectrophotometer (UV Thermo Spectronic) measuring the absorbance at 515 nm. The juice was previously centrifuged (HN-S centrifuge, International equipment company Needham, Mass. USA) for 10 minutes at 5000rpm. It was analyzed at 515 nm since anthocyanin pigments in water have maximum absorbance at this wavelength.

Table 1: Cranberries storage properties (Sydney Postharvest Laboratory and Food Science Australia, 2001)

Storage temperature	Relative humidity	%CO_2	%O_2	Respiration rate at 5°C	Respiration rate at 20°C
2-4°C	90-95%	1-2	0-5	1.67-2.00*	5.18-6.68*

*ml CO_2/kg/hr

Table 2: Manufacturers specifications of Cryovac, DuPont and Ziploc bags at 20°C

	Moisture permeability g/m^2/24h	O_2 permeability cc/m^2/24h
DuPont:Polyethylene/Nylon	295	60
Cryovac: High density polyethylene	15-20	2500
Ziploc: single layer freezer bag (polyethylene)	-	17000

Texture: As previously mentioned, texture is one of the main quality factors of food. Traditionally, for this parameter, cranberries are graded by bouncing down a slotted plank where the soft ones are rejected. For this study the texture characteristic of cranberries were determined by using a Kramer shear press with an Instron Universal Testing Machine. Three replicas were tested for each pouch and 6 for the control group, with 70g, making 2 layers of berries placed in the Kramer shear press cavity. A 50kN load cell with a crosshead speed of 160mm/min was used. Using the Young modulus, different parameters were obtained such as the young modulus, energy to break and toughness of the tested samples.

°Brix, pH and Moisture Content: The Brix degrees and pH were measured using a hand refractometer (0-90, Fisherbrand) and a pHmeter (Cole Parmer DL008). The moisture content of each sample was measured by the air oven method. For each treatment, three whole cranberries were placed for 24h in a convection oven set at 80°C.
A subjective analysis of the appearance of the fruits and the packaging material was also made, reporting the existence of water condensation, conditions of packaging and other anomalies.
At the end of the 16 weeks the gas content of the 4 bags was measured using a gas chromatograph (SRI GC – 8610A) with a Thermal Conductivity Detector (TCD).
The data were subjected to analyses of variance (ANOVA) and Least Square Difference test (LSD), using the Sigmaplot© and CoStat© software. The significance was accepted at $P \leq 0.05$.

Results and Discussion

Appearance: The visual appearance of the fruit revealed that the cranberries stored under vacuum looked better (Table 4). At the end of 16 weeks they showed a percentage of rejection inferior to 20% (Fig. 1). The control and the other non-vacuum packages at the end of the same storage period presented a rate of rejection greater than 50%.
The appearance of the vacuum bags was very satisfactory. This packaging made the cranberries look very appealing, light and fresh, which can be very convenient for marketing.
On the other hand the pressure of the bags for the vacuum packaging made the fruit release some moisture, so juice was found inside these packages in higher quantities than in the other packages. As the literature mentions the water condensation in the packaging is the proper environment for promoting microorganisms or fungal development. However, there was no visual indication of microorganism development. The packaging compaction and this tendering made the cranberries lose their spherical shape. Inside the packaging the surface of cranberries in contact with the others acquired an obtuse shape due to pressure. This shape distortion became less pronounced through the duration of storage as the packaging was loosened from the fruit respiration. The original form of

cranberries was reacquired minutes after opening the package and releasing the vacuum-pressure.

Brix and pH: The variation of °Brix was significantly influenced by the type of packaging material and the storage time (Table 3). Lowest °Brix was experienced with the vacuum packed cranberries (Fig. 2). The variation of pH was not significantly influenced by the packaging material but was significantly affected by

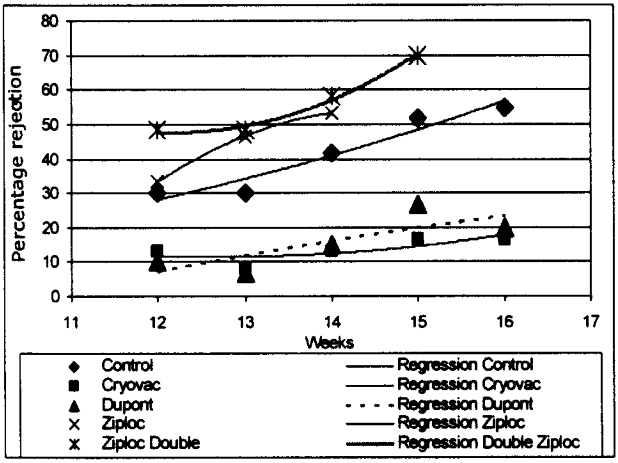

Fig. 1: Percentage of fruit rejection after visual inspection as a function of storage time and packaging material

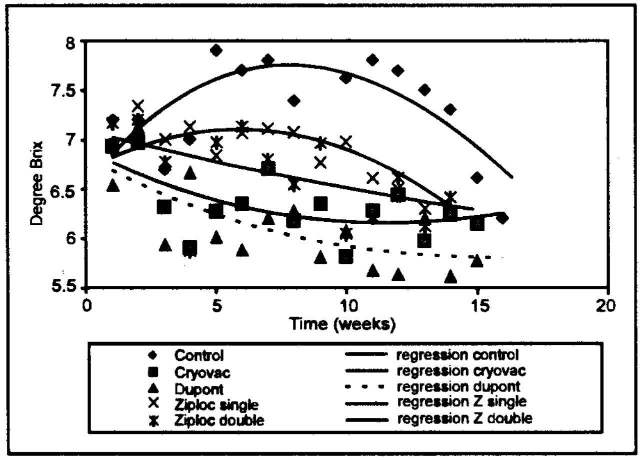

Fig. 2: Cranberry soluble solids content (°Brix) as a function of storage time and packaging material

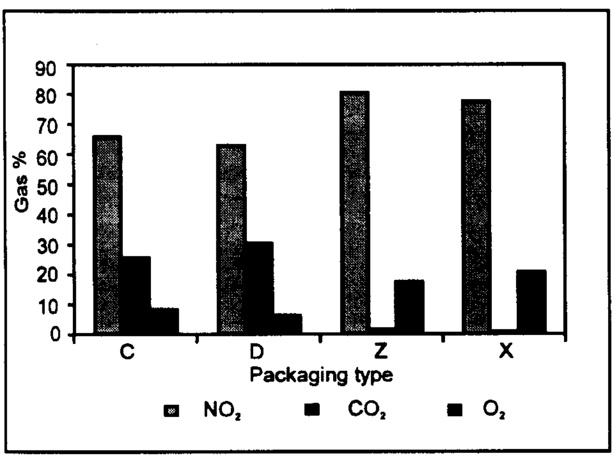

Fig. 3: Gas composition of the various kinds of packaging after 16 weeks of storage

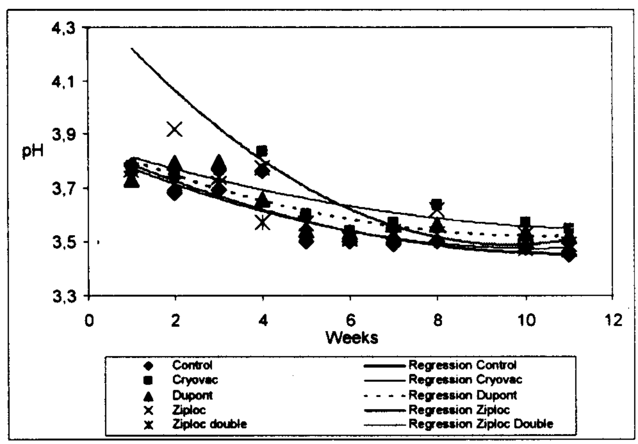

Fig.4: Cranberry pH as a function of storage time and packaging material

Table 3: Results from the ANOVA of some quality parameter measured for cranberries

Source	Pr >F												
Treatment	°Brix	pH	L*	a*	b*	C*	h°	ΔE	Eng. break.	Tough	Moist cont.	Color of juice	appearance
Treatment	***	ns	***	***	***	***	ns	*	***	***	***	***	***
Week	***	***	***	**	***	Ns	**	*	***	***	***	*	***
Treat*week	**		**	*	*				***	***			

*Significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level; ns non-significant

Table 4: Results from the ANOVA mean values for the 5 cranberries storage condition of some quality parameter measured during the experiment

Treatment	°Brix	pH	L*	a*	b*	C*	h°	ΔE	Eng. break (J)	Tough. (Mpa)	Moist cont.	Color of juice	appearance
Control	7.29^{a}	3.58^{b}	33.87^{a}	27.00^{bc}	9.96^{bc}	28.88^{bc}	035^{a}	4.69^{ab}	34.48^{a}	0.31^{a}	81.59^{c}	3.12^{a}	41.66^{h}
C	6.31^{a}	3.65^{ab}	32.02^{b}	31.73^{a}	13.31^{a}	34.24^{a}	036^{a}	4.08^{b}	27.86^{d}	0.25^{c}	82.31^{b}	4.20^{ab}	13.66^{c}
D	6.05^{d}	3.62^{ab}	31.28^{cd}	31.13^{a}	11.96^{a}	33.91^{a}	036^{a}	3.95^{b}	29.73^{bc}	0.27^{b}	82.04^{b}	3.94^{ab}	15.66^{c}
Z	6.86^{b}	3.74^{a}	31.73^{bc}	27.78^{b}	10.68^{b}	29.71^{b}	036^{a}	3.99^{b}	30.67^{b}	0.28^{b}	82.34^{ab}	3.72^{bc}	44.44^{b}
X	6.62^{c}	3.58^{b}	30.71^{d}	26.18^{c}	9.57^{c}	27.89^{c}	034^{a}	5.87^{a}	28.94^{cd}	0.27^{b}	82.81^{a}	3.52^{c}	56.24^{a}

Means within each column followed by different letters are different from each other ($P \leq 0.05$) by an ANOVA protected Least significant difference (LSD) test.
(C-Cryovac bag; D-Dupont bag; Z-Ziploc bag; X-Ziploc double layer bag)

storage time (Table 3 and Fig. 4) with a steady decrease of pH with time. There was no significant difference in final pH among treatments.
The mean values of the measurements for Brix reveal a small reduction in this parameter as O_2 is available for the cranberries due the permeability of the plastic membrane used for packaging. So a decrease in Brix follows the same order of the plastic permeability: Ziploc double layer (Z), Ziploc Simple (X), Cryovac (C) and Dupont (D). The plastic permeability was confirmed by the level of N_2 inside the pouches at the end of the 16 weeks storage (Fig. 3).

Moisture Content: As expected the non-packaged cranberries were the ones with the highest moisture loss at the end of the experiment (Fig.5). The packaging helped to reduce the transpiration therefore the weight loss. The high weight loss for the vacuum packaged cranberries at the beginning of the experiment can be explained by the expression of fruit juices which occurred in the vacuum-pressed packaging.

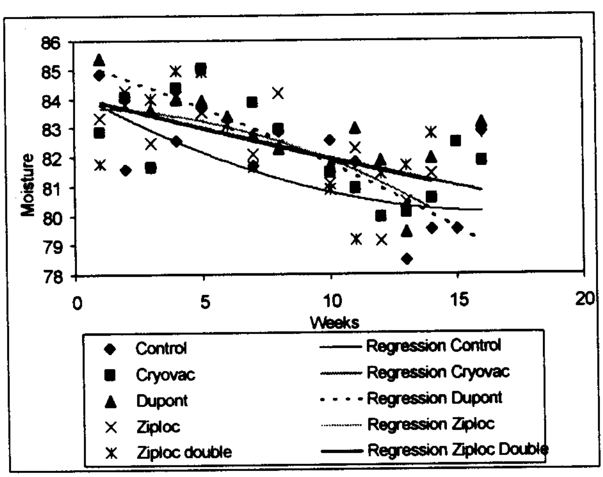

Fig. 5: Cranberry moisture content as a function of storage time and packaging material

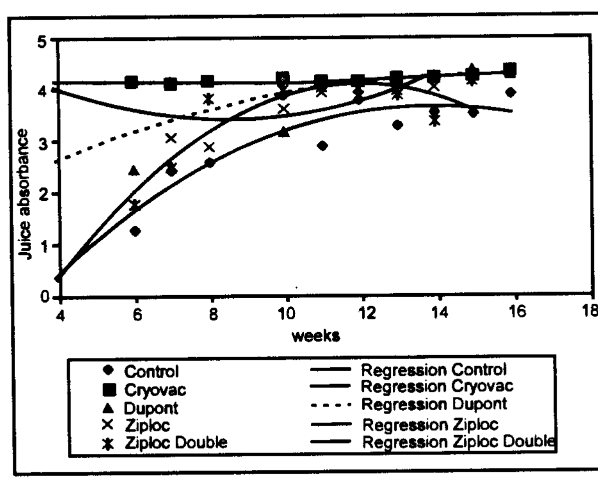

Fig. 6: Cranberry juice colour as a function of time and packaging material

Color: The ΔE parameter as indicator of surface color change reveals no statistical difference through time and as well not much difference between the five storage conditions (Table 3 and 4). Although we can say that the cranberries aerobically packaged Ziploc (Z) and the Ziploc double layer (X) had the highest change from the fresh fruit color. On the other hand, the vacuum packaged cranberries did not exhibit significant change through time. For the other surface color parameters, all showed a similar trend for the different treatments. It is possible to say that there was an increase of lightness (coordinate L*) for the control and an increase of redness (coordinate a*) for the vacuum treatments. This last observation confirms previous work that states that anaerobic conditions increase the anthocyanine content of cranberries (Eck, 1991). The pigment content was always higher for vacuum packaging than for the others. The juice color measured at 510 nm for anthocyanine content proves that there was an unquestionable increase of absorbance for all treatments through time (Fig. 6).

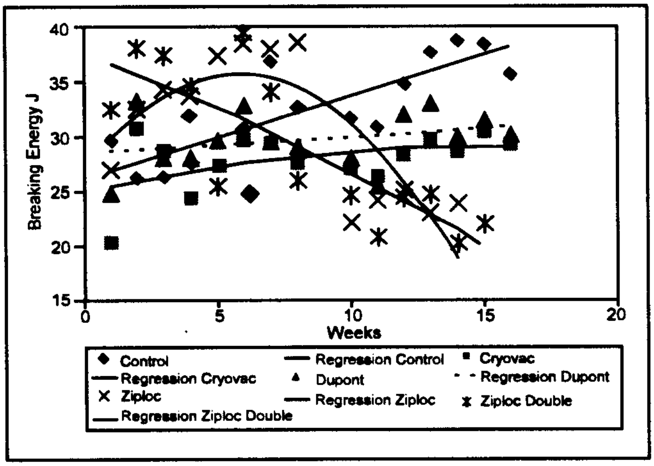

Fig. 7: Energy to Break cranberries as a function of storage time and packaging material

Texture: For all storage conditions a softening of the fruits after packaging (1st week) and stabilization through time for the non-vacuum packaged cranberries was evidenced. The juice found inside the bags promoted the softening of the fruits. However the energy necessary to break the fruit only decreased through time for the cranberries packaged aerobically in Ziploc films (Fig. 7). At the end of the experiment the non-packaged cranberries and the vacuumed packaged cranberries actually increased this parameter (Fig. 7).

Conclusion

Because of the increasing demand for cranberries up to the traditional (Thanksgiving and Christmas) consumption season this work presents a study of the post-harvest storage life of fresh cranberries stored in common plastic packaging material. Product quality indicators were monitored such as, color, pH, °Brix, texture, moisture content and general appearance of stored cranberries for 16 weeks, as influenced by the effect of different modified atmosphere conditions created by plastics films and cold storage.

The cranberries stored under anaerobic conditions revealed an increase of color intensity (anthocyanine content). These packages also showed cranberries with the lowest superficial color difference from the fresh cranberries, and a 30% less fruit rejection than cranberries stored under other conditions. The texture tests demonstrated an initial tenderness for vacuum packaging that did not increase with storage time as experienced by the other bags.

References

Anderson, R.E., R.E. Hardenburg and H.C. Vought, 1963. Controlled-Atmosphere Storage Studies with Cranberries. J. Amer. Sci. Hort. Sci., 83:416

Batagurky, S., G.S.V. Raghavan, J. Smith and V. Orsat, 1995. Film Packaging of Apples and Mangos. Agri. Eng. J., 4:41

Bourne, M.C., 1982. Food Texture and Viscosity-Concept and Measurement. New York. Academic Press pp: 325.

Brody, A.L., 1989. Controlled/Modified/Atmospheres/Vacuum Packaging Foods, (Ed), p.14. Food Nutrition Press, Inc. Trumbull, C.T.

Caruso, F. L., 1997. Trends in the Cranberry Production. Acta Horticulturae, 446:41-45.
Caruso, F. L. and D. C. Ramsdell, 1995. Compendium of Blueberry and Cranberry Diseases. Edited by Frank L. Caruso, Donald C. Ramsdell. American Phytopathological Society, St-Paul, Minnesota, USA. pp: 87.
Ceponis, M.J. and A.W. Stretch, 1983. Berry Color, Water-immersion Time, Rot, and Physiological Breakdown of Cold-stored Cranberries Fruits. HortScience, 18:484
Commission Internationale de l'Éclairage,C.I.E. , 1978. Recommendations on uniform color spaces, color difference equation - psychrometric color terms. CIE publication No.15(E-1.2.1) 1891/TC-1.3. Paris, France.
Cocatas, P., 1991. Promising Packaging. Agri. Eng.
Craker, L.E., 1971. Postharvest Promotion in Cranberries with Ethylene. HortScience, 6:137
Eck, P., 1991. The American cranberry. Rutgers University, New Brunswick, New Jersey, USA.
Francis, F.J. and G.J. Servadio, 1962. Relation Between Color of Cranberries and Stability of Juice. American Society for Horticultural Sci., 83:406
Francis, F.J. and F.M. Clydesdale, 1975. Food Colorimetry: Theory and Applications. Van Nostrand/ AVI Publishing, Westpork, Connecticut, USA, pp: 477.
Fudge, B.R., 1930. Increasing the Color of Cranberries after Removal from Vines. N.J. Agr. Exp. Sta. Bull, no 504
Graham, S.O., M.E. Patterson and B. Allen, 1966. Bruising as a Predisposing Factor in the Decay of Stored Cranberries. Phytopathology, 57:497
Gunes, G., R.H. Liu and C.B. Watkins, 2002. Controlled-atmosphere effects on postharvest quality and antioxidant activity of cranberry fruits. J. Agric. Food Chem. 50:5932-5938.
Gunness, C.J., H.J. Franklin and C.R. Fellers, 1941. Cranberries storage Investigations. Mass. Agr. Exp. Sta. Bul., 388:49
Hardenburg, R. E., A.E. Watada and C. Y. Wang, 1990. The Commercial Storage of Fruits, Vegetables and Florist and Nursery Stocks. USDA-ARS. Agricultural Handbook #66. pp: 130.
Hruschka, H.W., 1970. Physiological Breakdown in Cranberries- Inhibition by Intermittent Warming During Cold Storage. Plant Disease Reporter, 54:219
Kader, A.A., 1989. A Summary of CA Requirements and Recommendations for Fruits other than Pome Fruit. International Controlled Atmosphere Conference Fifth Proceedings, 14-16 June 1989 Wenatchee, Washington USA.
Kader, A.A., D. Zagory and E.L. Kerbel, 1989. Modified Atmosphere Packaging for fruits and vegetables. CRC Crit. Rev. Food Sci. Nutr., 28:1
Kuzminsky, L.N., 1996. Cranberry juice and urinary tract infections: is this a beneficial relationship?. Nutrition Reviews, 54:S87
Lees, R., 1975. Food Analysis: Analytical and Quality Control Methods for the Food Manufacturer and Buyer. CRC Press, Cleveland, USA. pp: 245.
Lockhart, C.L., F.R. Forsyth, R. Stark and I.V. Hall, 1971. Nitrogen Gas Suppress Microorganisms on Cranberries in Short Term Storage. Phytopathology, 61:335
McGuire, R.G., 1992. Reporting of Objective Color Measurements. Hortscience, 27:1254
Massey, L.M. and B.R. Chase, 1981. Impact-Induced Breakdown in Commercially Screened 'Howes' Cranberries. J. Amer. Sci. Hort. Sci., 106:200
Norton, J.S., A.J. Charing, and I.E. Demoranvielle, 1968. The Effect of Ozone on Storage of Cranberries. J. Amer. Sci. Hort. Sci., 93:792
Prince, T. A., 1989. Modified atmospheres packaging of horticultural commodities. In Controlled/Modified/Atmospheres/Vacuum Packaging Foods, Brody, A.L. (Ed), p.67. Food Nutrition Press, Inc. Trumbull, C.T.
Shamaila, M., W.D. Powrie and B.J. Skura, 1992. Sensory Evaluation of Strawberries under Modified Atmosphere Packaging (MAP) by Quantitative Descriptive Analysis. J. Food Sci., 57:1168
Sydney Postharvest Laboratory and Food Science Australia, 2001.http://www.postharvest.com.au
Stark, R., F.R. Forsyth, I.V. Hall. And C.L. Lockhart. 1971. Improvement of Processing Quality of Cranberries by Storage in Nitrogen. J. Can. Ins. Food Tech., 4:104
Swanson, B.G. and Weck, 1975. Refrigerated storage of fresh cranberries. J. Food Sci., 40:259
Vandenberg, J. and G. Parent, 1999. Profile of the Cranberry Industry. Market and Industry Service Branch – Agriculture and AgriFood Canada http:/www.agr.ca/misb/hort/pdf/cran.pdf