Table 2. Effect of 125 μg/ml galacturonic acid, pectin oligomers, DP 2-10 and pectin oligomers, DP > 10 in 0.1 M succinate or 0.1 M succinate alone (pH 5.0) on green 'Cherry' tomato ethylene production. All points are means of 4 replications.[1]

Treatment	nl C_2H_4 Fruit^{-1} hr^{-1} Hours after treatment 0	3	6	22
galacturonic acid	0.1a	66.7a	31.4a	10.1a
pectin, DP-10	0.2a	129.2bc	73.5bc	17.9a
pectin, DP > 10	0.2a	128.5c	71.0c	11.4a
0.1 M succinate	0.1a	35.4d	14.7d	3.5a

[1]Means followed by a common letter within columns for each time period are not significantly different at a 5% level of significance.

development (data not shown), was slightly accelerated by both the sugar and enzyme treatments.

There is no evidence that the terminal residues of cell wall polysaccharides have a critical function in cell wall structure, but it is possible that they could involve calcium crosslinks between adjacent pectin chains. Removal of such terminal ends by exo-PG action could lead to cell wall alteration (9). Either the products of exo-PG hydrolysis and/or the effect of exo-PG action on the cell wall could somehow signal the observed transient ethylene response.

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EFFECT OF TWO TYPES OF EDIBLE FILMS ON TOMATO FRUIT RIPENING

M. O. Nisperos and E. A.. Baldwin
U.S. Citrus & Subtropical Products Laboratory
600 Avenue S, N.W.
P.O. Box 1909
Winter Haven, FL 33883-1909

Additional index words. Durkex 500, TAL Pro-long, emulsifier, ethylene, CO_2, shelf-life, permeability.

Abstract. **Green tomatoes were coated with Durkex 500 or TAL Pro-Long, two edible fruit-coating materials that have shown promise in the preservation of fruit quality. The Durkex coating was applied with and without an emulsifier. TAL Pro-long film was applied at 4 different concentrations (0, 1, 1.5 and 2.0%, w/v). The coated fruits were stored at 70°F and periodically monitored for percent ripening, color, ethylene, and CO_2 production. Suppression of ripening was even more pronounced with the addition of an emulsifier. Fruits ripened abnormally resulting in uneven color development and blotchy appearance. TAL Pro-long coated fruits showed only a slight decrease in ripening. The fruits, however, exhibited a more uniform color development.**

The development of processes that retard and control ripening has been the subject of several investigations for many years. Most processes reported for the control of tomato ripening involve the use of gas, temperature and humidity control. The use of low temperature storage invariably caused chilling injury (9). Controlled atmosphere of low O_2 at 55°F extended the storage life of tomatoes for up to 87 days (8, 10). Hypobaric storage at 102 mmHg can lengthen storage life for 100 days provided the fruits are subsequently transferred to 646 mmHg at 55°F and 90 to 95% RH (11). These processes, however, are capital intensive and costly to run. An alternative process is to use an edible film. Edible film or coating is defined as thin layers of material which can be eaten by the consumer and provide a barrier to moisture, oxygen and solute movement for the food (3). Deliberate production and use of edible film that could retard ripening in a manner analogous to controlled storage is a recent concept in the fresh fruit and vegetable area. Extension of fruit or vegetable postharvest life would depend on the differential permeability of the coating to O_2, CO_2 and water which subsequently reduces metabolic rate and water loss (5). This study was initiated to determine the effects of two edible films on tomato fruit ripening.

Materials and Methods

Two split-plot experiments in a completely randomized design were conducted to determine the effect of two edible films on percent ripening, color, ethylene and CO_2 production of tomatoes. Mature green tomatoes (*Lycopersicon esculentum* Mill) cv. Sunny Asgro 674, obtained from a local source, were sorted visually for color and physical damage. Fruits were randomly divided into groups of 50 for the different treatments. The first experiment involved the application of Durkex 500 with or without EC-25 (50:50 v/v), an emulsifier. Durkex 500 is a non-lauric, stable vegetable oil blend while EC-25 is a propylene glycol ester of mono- and diglycerides with lecithin, BHA and citric acid. Both products were supplied by Durkee Industrial Foods Corp., Louisville, KY. Fruits for the second experiment were treated with TAL Pro-Long, a mixture of sucrose ester of fatty acids and sodium salt of carboxymethylcellulose (formulated by Courtaulds Group, London) at varying concentrations (0, 1, 1.5 and 2.0%, w/v) and then allowed to dry at ambient temperature prior to storage. All films were applied using a domestic paint brush. Fruits from both experiments were stored at 70°F. During sampling and testing, 8-10 fruits were obtained and held in an air blast freezer maintained at 0°F prior to analyses. Evaluation of percent ripening, color, ethylene and CO_2 began 5 and 6 days after storage for Durkex and TAL Pro-long coated fruits, respectively, and continued periodically for up to 20 days.

Percent ripening was obtained by periodic determination of the number of fruits exhibiting color change from green to pink or red, computed against the total number of fruits for that particular treatment. Color was determined by obtaining L, a and b values of whole fruit homogenate using a Minolta Chroma-Meter. Gas analyses were done by sealing individual fruit for 1 hr in a quart glass jar fitted with rubber septum. A one-ml gas sample was withdrawn from the headspace volume and analyzed for ethylene on a gas chromatograph (Perkin Elmer, Model 8500) equipped with an activated alumina column and a flame ionization detector. For CO_2, a 0.5 ml sample was injected into the same gas chromatograph, this time using Porapak S and molecular sieve columns along with thermal conductivity detection.

Data were analyzed by Analysis of Variance using the General Linear Model (GLM) procedure, a package program of the Statistical Analysis System (SAS Institute Inc., Cary, NC). Specific differences were determined by Tukey's Studentized Range (HSD). All comparisons were made at a 5% level of significance.

Results and Discussion

Results of the study showed that ripening was suppressed by the application of the vegetable oil blend, Durkex 500 (Fig. 1). A more pronounced degree of retardation was obtained for tomatoes treated with both the oil blend and the emulsifier, EC-25. By the 14th day of storage, 100% of the uncoated fruits exhibited signs of ripening, as determined by the subjective red color measurement of whole fruit. In contrast, only 80% and 40% of the fruits coated with Durkex and Durkex + EC-25, respectively, showed evidence of ripening. Objective color measurement (represented by a values for degree of redness) of whole fruit homogenate indicated that red pigment synthesis occurred earlier and to greater degree in uncoated fruits compared to either film treatments (Fig. 2). Significant reduction in ethylene production was observed for coated fruits ($Pr < 0.01$), as shown in Fig. 3. A similar trend was observed for CO_2 production except that on the 8th day of storage, uncoated and Durkex 500 coated fruits showed no differences in this property (Fig. 4). Although Durkex was effective in retarding tomato ripening, its suitability as an agent for postharvest life extension needs further investigation. Most of the Durkex-coated fruits developed blotchy appearance and stem-end rot. For this reason, no data was gathered beyond the 8th day of storage. The lipid film may have reduced gas exchange which resulted in anaerobiosis and other related physiological disorders in the tomato fruit. The addition of emulsifier, however, markedly improved permeability resulting in better color development and reduction of pathogen invasion in coated fruits.

TAL Pro-long coated fruits showed accelerated ripening up to the 7th day of storage (Fig. 5). With the 2% treatment, however, a slight decrease in ripening was observed on the 9th day of storage. Internal red color measurement showed a similar pattern for the 2% treatment where relatively lower a values were obtained with prolonged storage (Fig. 6). Results for gas analyses indicated that the treated fruits exhibited higher production of eth-

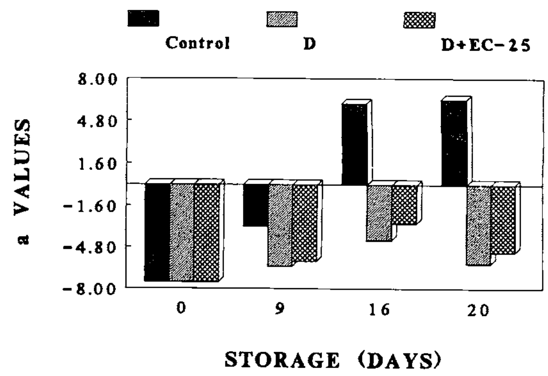

Fig. 2. Changes in red color development (indicated by a values) of tomatoes with a) no coating, b) Durkex 500 coating and c) Durkex 500 + EC-25 during storage at 70°F.

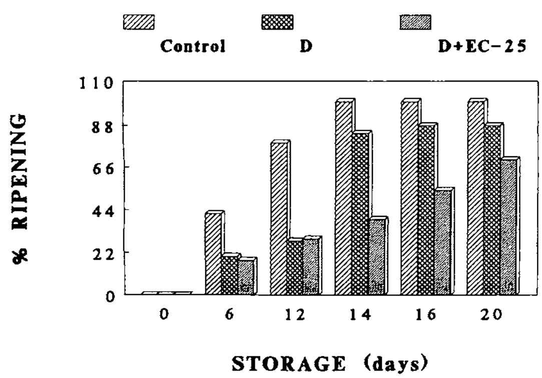

Fig. 1. Percent ripening of tomatoes with a) no coating, b) Durkex 500 coating and c) Durkex 500 + EC-25 coating during storage at 70°F. All figures were computed against 50, the number of fruits per treatment.

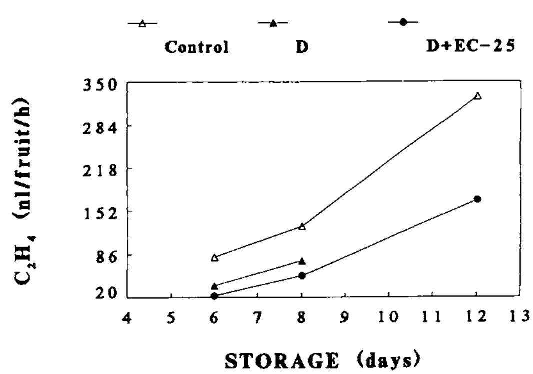

Fig. 3. Ethylene production of tomatoes with a) no coating, b) Durkex 500 coating and c) Durkex 500 + EC-25 coating during storage at 70°F.

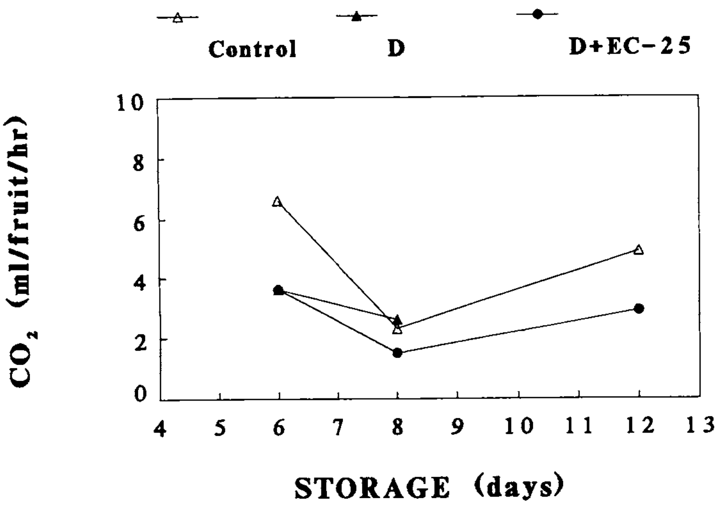

Fig. 4. CO_2 production of tomatoes with a) no coating, b) Durkex 500 coating and c) Durkex 500 + EC-25 coating during storage at 70°F.

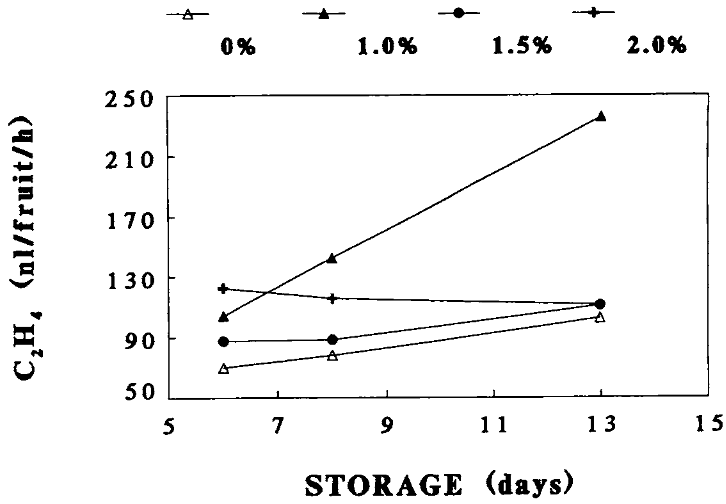

Fig. 7. Ethylene production of tomatoes coated with a) 0, b) 1, c) 1.5 and d) 2% TAL Pro-long during storage at 70°F.

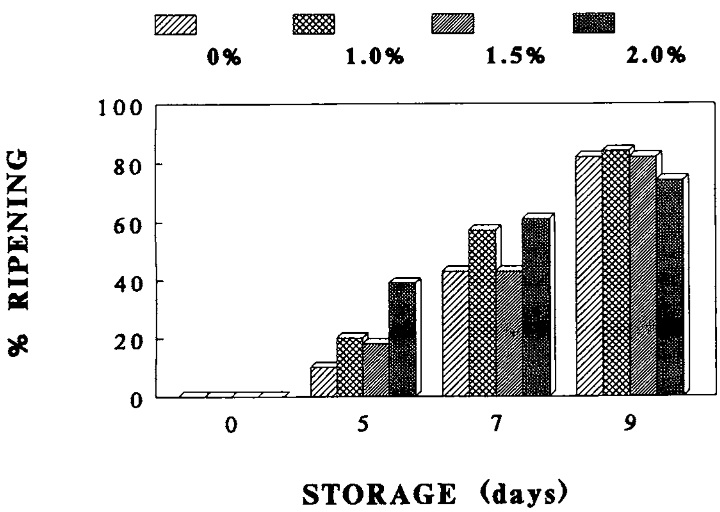

Fig. 5. Percent ripening of tomatoes coated with a) 0, b) 1, c) 1.5 and d) 2% TAL Pro-long during storage at 70°F. All figures were computed against 50, the number of fruits per treatment.

ylene and CO_2 ($Pr < 0.01$) (Figs. 7 and 8). This increased gas production is indicative of accelerated ripening, a pattern similar to that observed for the coated fruits during the earlier part of the storage period. No reduction in gas production was, however, observed for the 2% treatment even with prolonged storage. This discrepancy in results may be due to an interaction between the fruit and the coating (4) resulting in a wound ethylene response for the 1% coating. However, since this film is only semi-permeable to oxygen, the thicker coatings may have reduced oxygen uptake by the fruit thereby partially inhibiting the wound ethylene response observed for the 1% treatment. Earlier studies have demonstrated that this edible coating was effective in extending the shelf-life of bananas (1, 5), limes (7), mangoes (2) and pears (6). For tomatoes, suppression of ripening occurred only at the highest concentration of the test film and only toward the end of the storage period. The ripened fruits, however, were of better quality in contrast to those obtained from Durkex films. The fruits showed uniform color development with no occurrence of fungal growth. The inferior performance of the film in retarding ripening can be traced to its inability

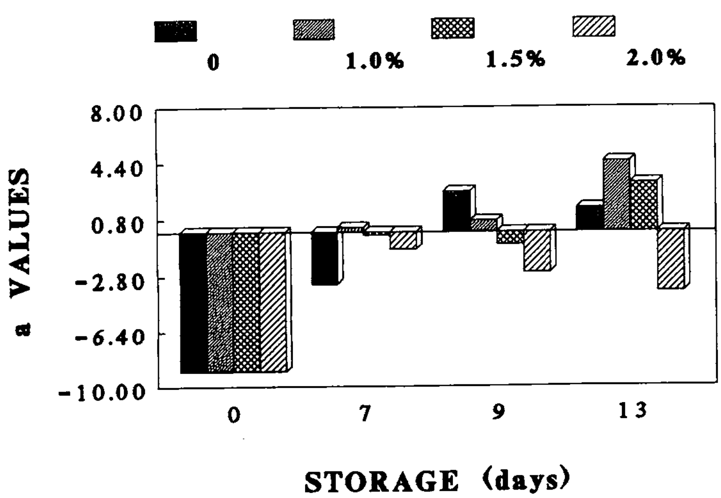

Fig. 6. Changes in red color development (indicated by a values) of tomatoes coated with a) 0, b) 1, c) 1.5 and d) 2% TAL Pro-long during storage at 70°F.

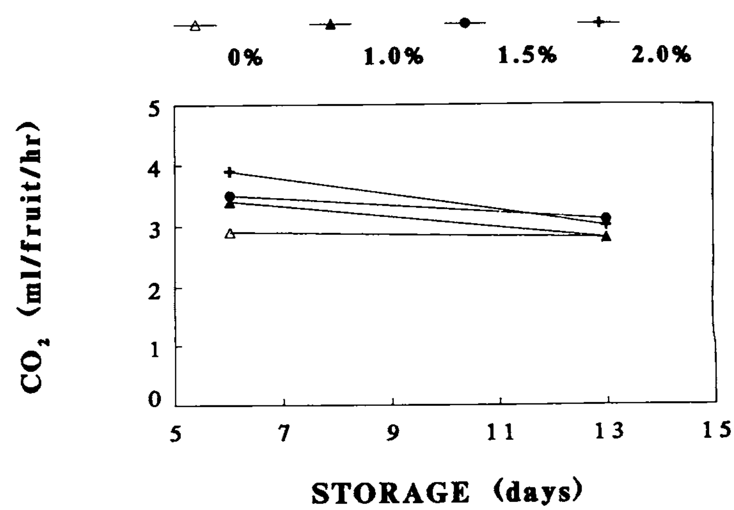

Fig. 8. CO_2 production of tomatoes coated with a) 0, b) 1, c) 1.5 and d) 2% TAL Pro-long during storage at 70°F.

to form a complete, uniform coating around the surface. The addition of a surfactant or an emulsifier may greatly increase the ability of the film to suppress ripening.

In the light of these results, it is recommended that further studies be conducted on improving permeability characteristics of both films by developing new formulations and by establishment of proper application procedures. More information should also be gathered on the influence of these films on fruit desiccation, onset of microbial growth and other associated physiological processes of ripening.

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WORKSHOP
HANDLING AND PROCESSING SECTION

Technological Advancements in Packaging

1. Technological Advancements in Developing Improved Packaging for the Processed Fruit and Vegetable Industry, Rex Turner, Manager, Technology and Product development, International Paper Co., Memphis, TN.

ABSTRACT: Generic package performance criteria of recently developed multi-layer paperboard plastic composite structures (Barrier Pak[R]) were reviewed. These materials engineered packages provide improved product quality maintenance over the packaged product shelf life. A process of product development for optimizing product specific packages was presented. Related packaging manufacturing processes, terminology definitions, and technical development capability was incorporated in the presentation and discussion.

2. Recent Developments in Improving the Storage Life of Fresh Fruits and Vegetables by Application of Plastic Films and Modified Atmospheres to Master Shipping Containers, Mike Mykleby, Vice-President, CVP Systems, Inc., Downers Grove, IL.

ABSTRACT: Developments in the use of modified atmospheres for fresh food packaging, and why it is more difficult to "do it right" when packaging fresh fruits and vegetables than it is for pork or chicken meat was presented. Vegetables, for example, are respiring and the levels of oxygen and carbon dioxide have to be controlled in order to obtain significant extended shelf life. Recent developments in plastic films and machinery that make possible "master packing" (many small packages inside a larger master container or bag) were described and discussed, and viable systems and solutions presented. Advancements in bulk packaging and use of modified atmospheres for fresh foodstuffs during the movement of commodities from production areas to sites of further processing for purposes of maintaining high product quality were also presented.

3. Packaging for Profit for Product Protection, Tom Green, Northeastern Regional Manager, Food Packaging System, Weldotron Corporation, Piscataway, NJ.

ABSTRACT: The addition of attractive and beneficial packaging material to fresh fruits and vegetables enhances added product value. In today's market, the cost of packaging materials used for a given commodity may surpass the cost of the product being put into the package. Packaging material properly conceived, color selected, and labeled can enhance product quality characteristics and will greatly improve product presentation and promote point of purchase sales. A great selection of various plastic films are available for use on fresh foodstuff which, when properly selected and applied, will enhance overall freshness and extend shelf life. Machinery is now available which will allow the use of plastic film in high speed packaging tasks for some fresh commodities which, until recently, were a very labor intensive activities. Examples include the packaging of blueberries and mushrooms in various size consumer baskets.

4. Principal Postharvest Handling and Packaging Considerations for Successful Marketing of Mango and Other Major Tropical Fruits Grown in South Florida, Craig A. Campbell, J. R. Brooks and Sons, Inc., Homestead, FL.

ABSTRACT: Mango, carambola, papaya, lychee, atemoya, and mamey are six of the principal tropical fruits grown and marketed in South Florida in addition to lime and avocado. Where some of these fruits have been sold commercially for decades, others have a very short history in the marketplace. Handling these various commodities presents new challenges to packinghouse managers, traffic managers, and salespeople, all of whom must learn the special requirements for each fruit. Growers in South Florida are producing many unique tropical fruits that are being marketed by a handful of fruit companies. Most of these species have been present for decades as dooryard