

Developing a Value-added Fresh-cut 'd'Anjou' Pear Product

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SUMMARY. We have established that 'd'Anjou' pears (*Pyrus communis*) are properly ripened for fresh-cut use when flesh firmness (FF) is between 5 lb (2.3 kg) and 7 lb (3.2 kg). In this study, the fruit was ripened in air enriched with 100 ppm (mL·L⁻¹) ethylene at 68 °F (20.0 °C). Afterward, we investigated three slicing methods, each employing a fruit sectionizer for dividing individual pears into eight wedges. The easiest and most convenient cutting procedure involved pouring an antibrowning agent onto the incision, but without allowing the fruit to directly contact the air. We evaluated various combinations of L-ascorbic acid (vitamin C) and potassium chloride (KCl) for their ability to prevent any discoloration while also not affecting taste or injuring the cut surface. The most suitable antibrowning solution contained 10% L-ascorbic acid and 2% KCl (pH 2.3). A dipping time of 30 s was sufficient for maintaining the wedges with little discoloration over a 14-d period, at either 30 or 35 °F (-1.1 or 1.7 °C). Here, we also present a prototype design for a 1.6-pt (0.76-L) transpar-

ent plastic container with eight compartments for holding wedges sliced with a commercially available sectionizer.

The pear industry urgently needs to create an innovative sales strategy for newly harvested 'd'Anjou' fruit to ease distribution pressures at a time when South American pears are appearing in the retail markets. To increase their unit prices, this fruit must possess good dessert quality that satisfies consumers' expectations. Poor ripening of 'd'Anjou' pears is an obvious deterrent to purchase. Moreover, most shoppers do not know how to ripen this variety, even though the Pear Bureau Northwest (Milwaukie, Ore.) has long promoted various educational activities.

Fresh-cut fruit in general has become a very popular commodity because its packaging is very convenient for busy consumers. Most recent research on fresh-cut pears has been focused on developing antibrowning solutions and designing various modified-atmosphere containers to prolong shelf life (Dong et al., 2000; Gorny et al., 1998, 2000; Rosen and Kader, 1989; Sapers and Miller, 1998; Senesi et al., 1999). However, the primary purpose in marketing the fresh-cut product is to stimulate the consumers' desire to purchase and quickly consume minimally processed foods. Therefore, an extended shelf life is unnecessary. To make 'd'Anjou' pears a more desirable fresh-cut product, the industry must develop a functional package that protects the ripened fruit wedges from physical damage while maintaining high dessert quality and healthy appearance over a sufficient shipping and marketing period.

Although urban schools with limited food-service facilities sometimes find it difficult to serve fresh fruit with preplated meals, public schools in Elizabeth, N.J. have reported that children will eat fruit cut into wedges (School Foodservice Journal, 1978). With a growing emphasis on healthful living, consumption of fresh fruit, cheese, and yogurt is being lauded (Woicik, 1978). Creative packaging of fresh-cut 'd'Anjou' fruit in combination with cheese or yogurt would provide a tasty, nutritious snack or dessert, and would also stimulate sales of pears during the marketing season, thereby ensuring a

profitable cash return to growers and shippers.

The objectives of this study were to 1) determine the level of ripeness in 'd'Anjou' pears that makes them most suitable for retail as a fresh-cut product with an adequate shelf life; 2) identify the optimum food-grade antibrowning solution for preventing wedge discoloration, without affecting taste and integrity; 3) develop an innovative procedure for slicing the ripened fruit without causing oxidative browning on the cut surface; and 4) design a convenient package that retains the high quality of fresh-cut wedges, and provides consumers with an attractive product as well as a wholesome, healthy snack.

Materials and methods

DETERMINING PROPER RIPENESS FOR FRESH-CUT MARKETING. We purchased six boxes of commercially packed 'd'Anjou' pears [uniform size of 90 fruit per 44-lb (20.0-kg) box] from the Duckwall-Pooley Fruit Company, Odell, Ore. on 13 Apr. 2001. These presized fruit had previously been kept in a controlled atmosphere (CA). Company policy precluded us from obtaining detailed information about those storage conditions. At the Mid-Columbia Agricultural Research and Extension Center in Hood River, Ore., we placed the boxes in a ripening room at 68 °F, where the air was enriched with 100 ppm ethylene. Two randomly selected boxes constituted one replicate, for a total of three replicates. Each day thereafter, for 10 d total, we removed 10 fruit from each replicate (five per box) in order to assess any changes in flesh firmness (FF), dessert quality, and the levels of extractable juice (EJ), soluble solids content (SSC), and titratable acids (TA). Each 10-fruit sample was considered a single experimental unit.

To determine FF, we used the 0.31-inch-diameter (8.0-mm) plunger of a UC pressure tester (Claypool and Fridley, 1966). Surfaces were pared from both the sunny and the shady sides of each fruit, then perpendicularly penetrated, under steady force, to a depth of 0.35 inch (9.0 mm). For determination of extractable juice (EJ), soluble solids content (SSC) and titratable acids (TA), fruit used for determination of FF were peeled and sliced, and 3.5 oz (0.1 kg) of flesh tissue was juiced in a juice extractor

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Table 1. Nine-point hedonic scale for rating the dessert quality and ripeness of 'd'Anjou' pears.

Score	Description
9	100% perfect ripeness: fruit has buttery and juicy texture, combined with flavorful taste and aroma
7	75% perfect ripeness and 25% underripeness or overripeness
5	50% perfect ripeness and 50% underripeness or overripeness
3	25% perfect ripeness and 75% underripeness or overripeness
1	0% perfect ripeness: fruit was held for 1 d at 68 °F (20.0 °C) after having been removed from cold storage at 30 °F (-1.1 °C). At this stage, flesh firmness is usually between 14 lb (6.4 kg) and 12 lb (5.4 kg), depending upon the length and type of storage. Unripened fruit has a crisp texture and very flat flavor (including taste and aroma).
1	100% overripeness: ripened fruit has a mealy, coarse, and dry texture, combined with an off flavor.

(model 6001; Acme Juicer Manufacturing Co., Sierra Madre, Calif.) for 1 min (Chen and Mellenthin, 1981). EJ was measured in a 100-mL graduated cylinder and expressed on a fresh weight basis as mL/100g. SSC was read by a hand refractometer (Atago; NSG Precision Cells, Inc., Hicksville, N.Y.). TA was determined by titrating 10 mL of juice to pH 7.2 using 0.1 N sodium hydroxide and calculated as meq/100 mL (Chen and Mellenthin, 1981).

Dessert quality, including flesh texture and flavor (i.e., acid/sugar balance and aroma), was rated on a nine-point hedonic scale (Table 1) (Heintz and Kader, 1983; McBride, 1986). One wedged sector per fruit sample was assessed by three sensory panelists trained for taste evaluations. Their quality scores per replicate were then averaged. A mean score of five or higher from the three replicates was considered commercially acceptable.

When the fruit were deemed ripened enough to have an acceptable quality, 20 per replicate were transferred to one of two rooms that were set at either 30 °F or 35 °F. In each room, the fruit were held for either 7 or 14 d to assess their extended shelf life at that ripening stage. After each holding period, 10 fruit (i.e., one experimental unit) per replicate were used for another determination of FF, EJ, SSC, and TA.

TESTING THE EFFICACY OF ANTIBROWNING SOLUTIONS. We evaluated the mixtures of different concentrations of L-ascorbic acid (Fisher Scientific, Inc., Fair Lawn, N.J.) and KCl (Sigma Chemical Co., St. Louis, Mo.) to determine their ability to counteract discoloration without either affecting taste or injuring the cut surface. A matrix was set up that comprised 15 different combinations of L-ascorbic acid (1%, 5%, 10%, 15%, and 20%) and KCl (2%, 4%, and 6%). The acidity of each solution was measured with a pH

meter (ion analyzer model 255; Corning Science Products, Corning, N.Y.). To prevent browning before beginning the experiments, composite wedges from 10 properly ripened pears were sliced under a 1.0% L-ascorbic solution, using a commercial fruit sectionizer (EKCO Housewares, Inc., Franklin, Ill.). Eighty sliced wedges were gently transferred onto a tray lined with four layers of cheesecloth to absorb any excessive 1.0% L-ascorbic solution on the wedge surfaces. Five randomly selected wedges were dipped for 30 s into one of the 15 antibrowning mixtures [16.9 fl oz (500 mL)]. The treated wedges were then placed in a plastic container, covered with perforated polyethylene film, and stored at 30 °F. After being held for 14 d, the wedges were examined for injury to their edges and cut surfaces. The degree of damage was classified as: clear (no injury), slight (small discoloration on either the cut surface or the edge), and severe (discoloration on both the cut surface and the edge). To confirm this visual assessment, color photographs were taken immediately after treatment began (day 0) as well as after the wedges had been held for 14 d.

DEVELOPING FRESH-CUT PROCEDURES. For the fresh-cut experiments, we used fruit that had been adequately softened to rate a dessert quality of acceptable. Each pear was divided into eight wedges with the EKCO fruit sectionizer, using one of three cutting methods to determine which was most effective in protecting the cut surfaces from browning. In the first method (inverse cutting), the sectionizer was inverted on top of a 500-mL beaker filled with one of the antibrowning solutions. The fruit (stem end facing down) was then gently pushed and sliced into the beaker. The second method (submerged cutting) involved sinking the entire piece of fruit (stem

end up) into the antibrowning solution, then slicing from the stem to the calyx. In the third method, only half of the fruit sample was submerged (stem end up) in the solution, then sliced down to a depth equal to the width of the sectionizer blade. This was followed by quickly pouring a small amount [about 0.3 fl oz (10 mL)] of antibrowning solution into the incision. When the fruit had been sliced half-way through, about 0.7 fl oz (20 mL) of solution was again quickly poured into the deeper incision. The entire piece of fruit was then sliced into the antibrowning solution.

DETERMINING THE SHELF LIFE OF FRESH-CUT RIPENED 'd'ANJOU' SLICES.

For this evaluation, we purchased an additional three boxes of presized, commercially packed, CA-stored 'd'Anjou' pears (size 90) from the Duckwall-Pooley Fruit Company on 13 Apr. 2001. We temporarily held these fruit at 30 °F for 14 d, then placed them in a ripening room that was enriched with 100 ppm ethylene at 68 °F. Ten pieces of fruit (one experimental unit) were removed daily from each box for assessing FF and dessert quality. When the fruit had softened to the proper ripeness with acceptable quality, we sliced them according to the third cutting method (i.e., pouring the antibrowning solution onto the incision). The wedges were then held in that mixture for 30 s.

Afterward, eight wedges from each individual fruit were gently transferred into a strainer lined with four layers of cheesecloth, then positioned upright in a 1.6-pt transparent plastic container (Rubbermaid Inc., Wooster, Ohio). The skin side of each wedge was leaned against the container wall, while the top portion was tilted, about 30° away from the center axis, to form a lotus-flower shape. The container was covered with a lid that had a 0.13-inch-diameter (0.32-cm) perforation.

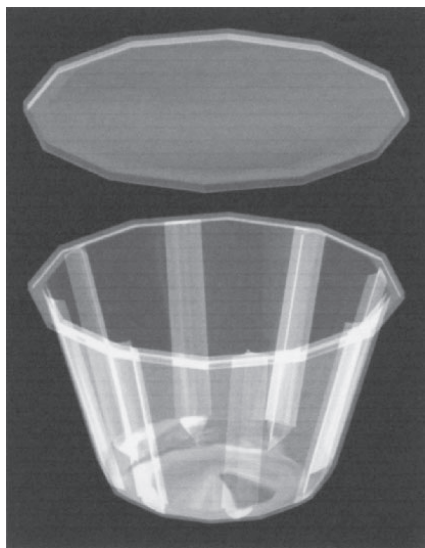


Fig. 1. Prototype of a transparent container designed for fresh-cut 'd'Anjou' pear wedges.

Ten of these packed containers (each considered a single experimental unit) were stored in one of two rooms, at either 30 or 35 °F. After holding them for 7 or 14 d at one of those experimental temperatures, five containers from each room were assessed for browning and dessert quality. Discoloration was determined visually by panelists using the nine-point hedonic scale of Gorny et al. (2000), with 9 = excellent (just sliced); 7 = very good; 5 = good, but with limited marketability; 3 = fair, with limited usability; and 1 = poor and inedible. Dessert quality was judged as described above. Panelists also evaluated the taste of one fruit wedge per container.

CONTAINER DESIGN FOR FRESH-CUT SLICES. We also designed a prototype for a 1.6-pt transparent plastic container, with eight compartments that house individual wedges sliced from a single pear with a commercially available sectionizer. This 4-inch-tall (10.2-cm) container has a curved, uneven cylindrical shape—4.5 inches (11.43 cm) in diameter at the upper opening, and 3 inches (7.6 cm) in diameter at the bottom (Fig. 1). The base is concaved to form a ditch-like reservoir so that any excess antibrowning solution can be easily drained to prevent damage to the cut surfaces. The container can be sealed with a perforated lid (total area of its air holes equaling an open diameter of 0.13 inch), which allows some gas exchange between the container and ambient air. The fruit wedges in this

prototype are also positioned in the upright configuration in each compartment so that any risk of bruising can be minimized during further transport.

STATISTICAL ANALYSES. NWA STATPAK 4.1 software (Northwest Analytical, Inc., Portland, Ore.) was used for our analyses. In the ripening study, we plotted the changes in FF, EJ, SS, and TA (as dependent variables) against the corresponding days of ripening at 68 °F (an independent variable). The following regression analyses were then determined: 1) linear, 2) exponential, 3) natural loga-

rithmic, 4) power law, and 5) polynomial. Afterward, the analysis with the highest significant r^2 (Steel and Torrie, 1960) was selected as the best fit for the changing pattern of each parameter during 10 d of ripening. For the other data, we used either the standard deviations or the range for comparing different measurements.

Results and discussion

IDENTIFYING THE PROPER RIPE-NESS OF 'd'ANJOU' PEARS FOR FRESH-CUT PRODUCT. The softening pattern of the fruit followed a natural logarithmic regression when held for 10 d at

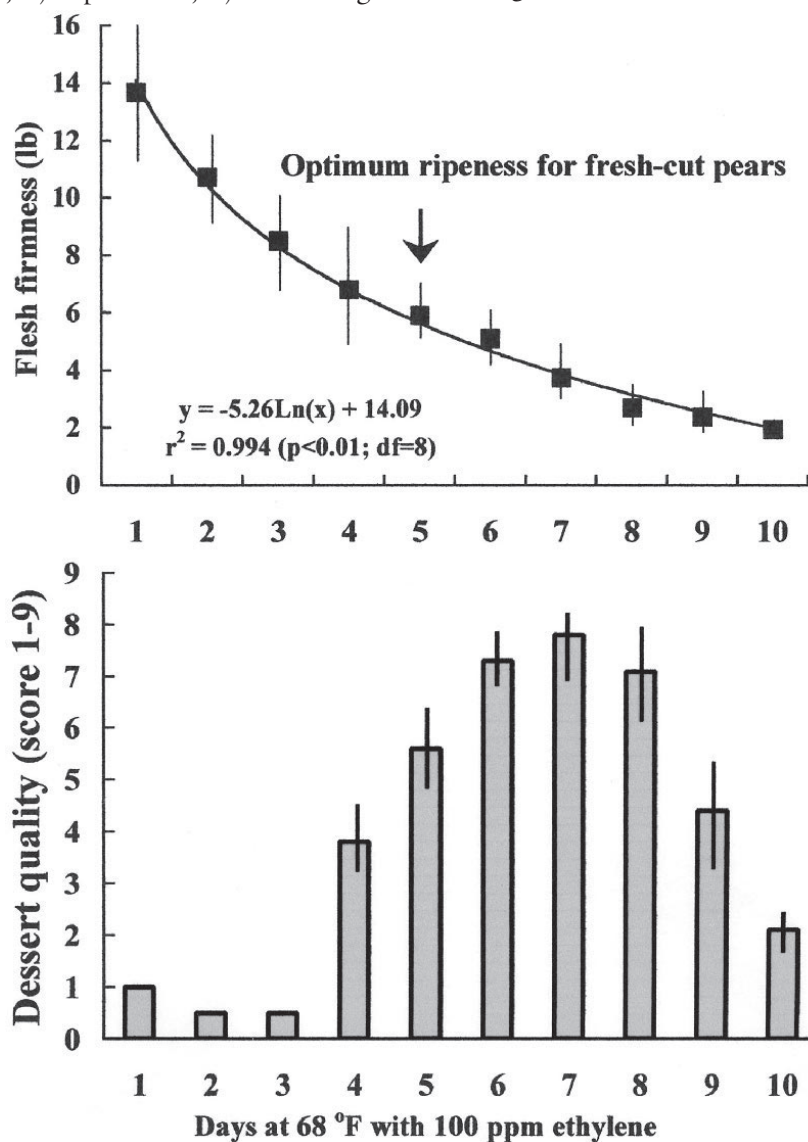


Fig. 2. Fruit-softening pattern (i.e., changes in flesh firmness) and overall dessert quality of 'd'Anjou' pears during 10 d of ripening in air enriched with 100 ppm (mL·L⁻¹) ethylene at 68 °F (20.0 °C). Vertical bar at each data point represents the range of firmness and overall quality. Flesh firmness was determined by using the 0.32-inch-diameter (8.0-mm) plunger of a UC pressure tester (Claypool and Fridley, 1966). Surfaces were pared from both the sunny and the shady sides of each fruit, then perpendicularly penetrated, under steady force, to a depth of 0.35 inch (9.0 mm). See Table 1 for description of nine-point hedonic scale for rating quality.

Table 2. Changes in flesh firmness (FF), extractable juice (EJ), soluble solids content (SS), and titratable acids (TA) of 'd'Anjou' pears that were first ripened at 68 °F (20.0 °C) for 5 d, then held at 30 °F (−1.1 °C) or 35 °F (1.7 °C) for 7 or 14 d.^z

Temp (°F)	Day	FF (lb) ^y	EJ (mL/100 g fresh wt) ^y	SSC (%) ^y	TA (meq/100 mL) ^y
30	7	5.2 ± 0.4 ^x	61.4 ± 1.3 ^x	14.2 ± 0.3	3.1 ± 0.7
	14	3.8 ± 0.3	58.2 ± 0.8	13.8 ± 0.5	2.9 ± 0.6
35	7	4.3 ± 0.3	59.5 ± 1.6	14.1 ± 0.6	2.9 ± 0.4
	14	2.1 ± 0.2	60.7 ± 1.1	14.2 ± 0.4	2.7 ± 0.3

^zPears had previously been stored in a commercial, controlled-atmosphere room for 8 months before being purchased from the Duckwall-Pooley Fruit Company, Odell, Ore., on 13 Apr. 2001.

^yValues are the means ± standard deviation.

^x1.0 lb = 0.45 kg, 1.0 mL/100 g = 0.15 fl oz/lb.

68 °F in our ripening environment (Fig. 2). At day 5, FF was 6 lb (2.7 kg) and overall dessert quality (including texture and flavor) had increased to an acceptable score of 5.6. Because the shelf life of the 'd'Anjou' fruit slices was expected to be 7 d at 35 °F, we considered the FF recorded at this stage to be the optimum level of ripeness for fresh-cut purposes.

When the uncut pears that had already reached an FF of 6 lb were then held at 30 °F or 35 °F for 7 d, they continued to soften to FFs of 5.3 lb (2.40 kg) and 4.3 lb (1.95 kg), respectively (Table 2). By day 14, the FF readings were 3.8 lb (1.72 kg) and 2.1 lb (0.95 kg), respectively. The effect of temperature on the softening of pear fruit has been well documented (Porritt, 1964). Fresh-cut 'd'Anjou' wedges might have softened even faster at the same temperature because wounding at the cut surface would induce ethylene production, which, in turn, accelerates the ripening process. Gorny et al. (2000) and Rosen and Kader (1989) reported that fresh-cut pear wedges respired at a higher rate than did whole pears, but the levels of ethylene production did not differ significantly between those two products. Rosen and Kader (1989) speculated that the pear fruit used for their fresh-cut study had reached the advanced (postclimacteric) stage of ripeness that wounding response for ethylene biosynthesis diminished.

Sapers and Miller (1998) reported that the minimum acceptable FF for fresh-cut 'd'Anjou' pears is 8.8 lb (4 kg), while Dong et al. (2000) suggested that 9.7 lb (4.40 kg) is more suitable. In our study, however, fruit that softened to an FF of 9 lb (4.1 kg) to 11 lb (5.0 kg) had a rubbery texture and very flat flavor. In fact, their overall dessert quality was arbitrarily scored as 0.5 after being held for 1 or 2 d at 68

°F (FF between 9 and 11 lb), simply to indicate that their rating was worse than that of unripened fruit (i.e., as would have been recorded on day 1 of the ripening treatment; Fig. 2).

The first-day quality of fresh-cut pear slices is crucial when this product reaches the retail market because it is this impression the consumer will rely on when making the decision to purchase such fruit. Therefore, we propose that fresh-cut 'd'Anjou' products are properly ripened when the FF decreases to between 7 lb and 5 lb. Ripening pear fruit in an environment enriched with 100 ppm ethylene was essential to developing the most uniform firmness. Puig et al. (1996) have described using ethylene to synchronize the ripening of individual 'Bartlett'

pears. This is done to maximize case yields in commercial canning process. Similarly, softening individual 'd'Anjou' fruit to a uniform firmness provides consumers with consistent dessert quality in each package of fresh-cut slices.

Softening and dessert quality continued to improve from days 5 to 7 during our ripening treatment (Fig. 2). Quality started to decline at day 8 (score of 7.1), and the fruit then became overripe, with scores of only 4.4 and 2.1 after being held for 9 and 10 d, respectively, at 68 °F. Fruit that had reached an average FF of ≤5 lb became too soft for fresh-cut purposes because the shelf life would have been very short for wedges at this stage of ripeness.

Over the 10-d ripening period, the process of fruit softening was associated with an initial decline in extractable juices (EJ) through day 8, followed by a gradual increase in EJ content (Fig. 3). A second-order polynomial regression gave the best fit and the highest r^2 value (0.915). Chen and Borgic (1985) have demonstrated that

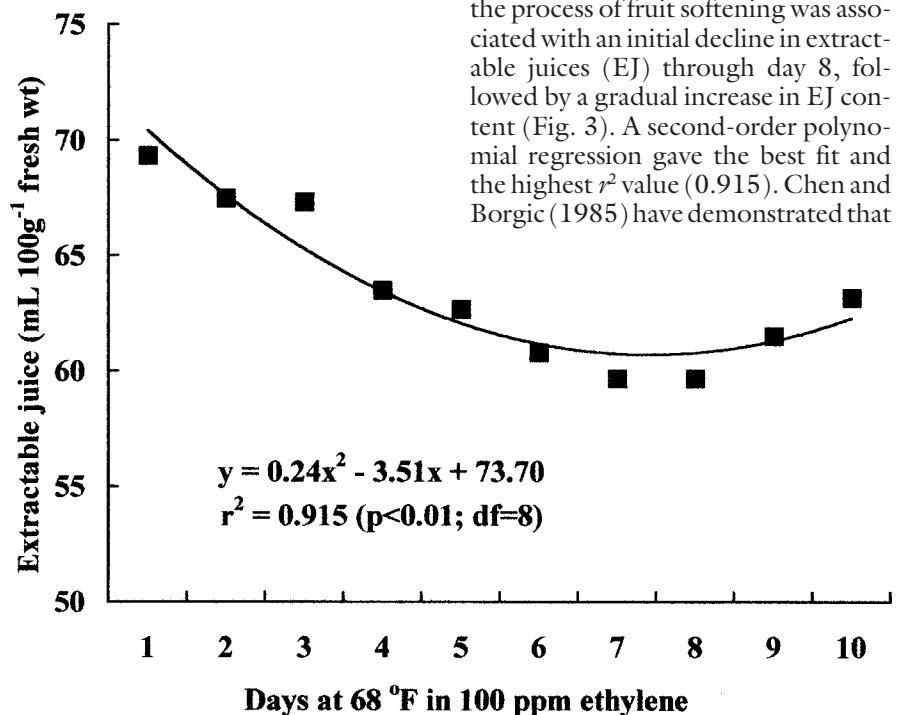


Fig. 3. Changes in extractable juice of 'd'Anjou' pears during 10 d of ripening in air enriched with 100 ppm (mL·L^{−1}) ethylene at 68 °F (20.0 °C); 1.0 mL/100 g = 0.15 fl oz/lb.

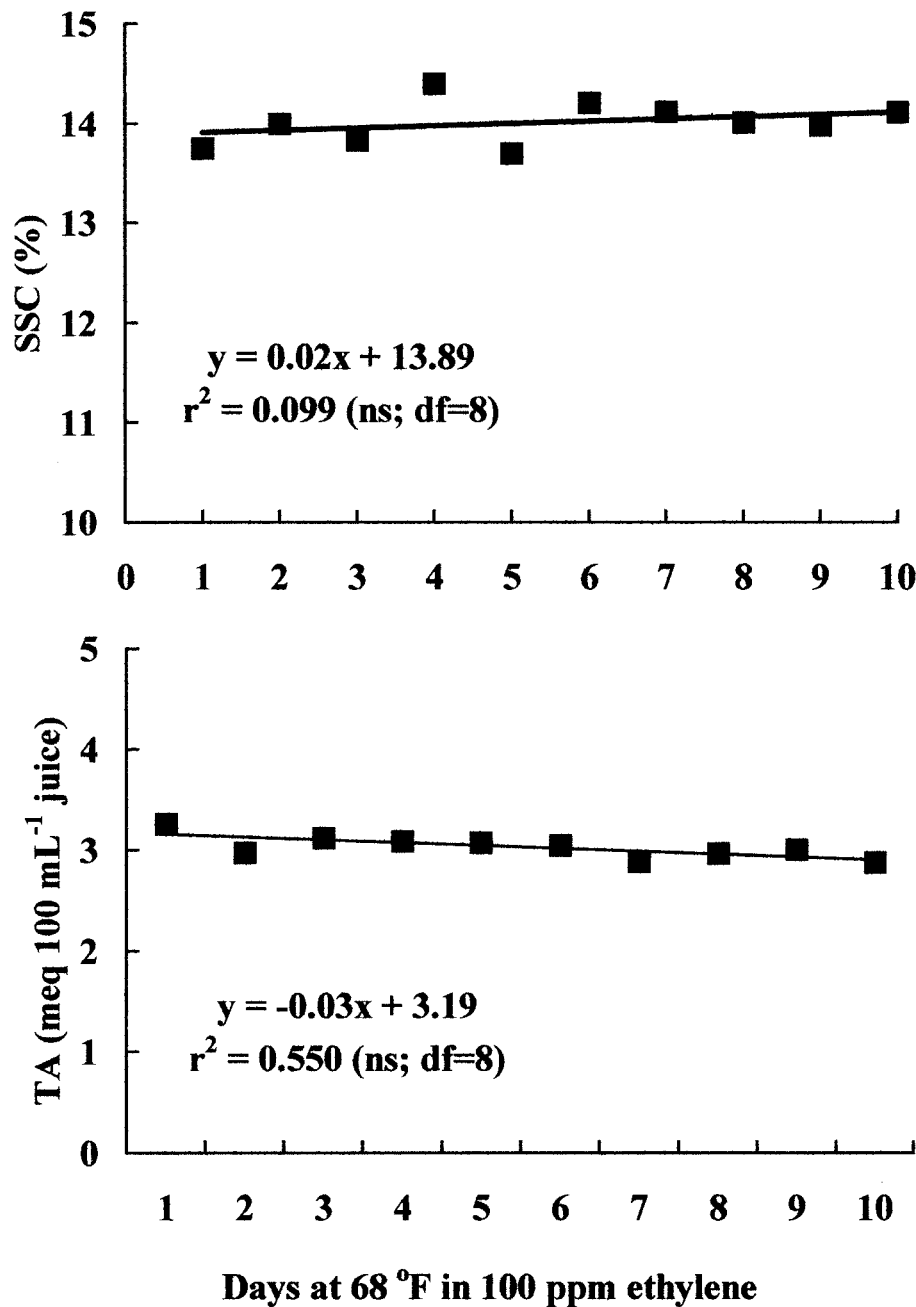


Fig. 4. Changes in soluble solids content (SSC) and titratable acids (TA) of 'd'Anjou' pears during 10 d of ripening in air enriched with 100 ppm (mL·L⁻¹) ethylene at 68 °F (20.0 °C).

this measurement of EJ is an objective means for evaluating textural quality. Water-soluble polyuronides in the pulp tissues increase dramatically during the normal ripening process, resulting in an apparent rise in hygroscopic binding capacity. This phenomenon is consistent with an apparent reduction in juice content when the fruit arrives at the proper ripeness. Those pears that have a buttery and juicier texture usually show a greater decrease in EJ than

do partially ripened fruit that are chewy, coarse, and dry.

Soluble solid contents (SS) did not change significantly during 10 d of ripening, remaining at about 14% (Fig. 4). The amounts of titratable acids decreased slightly during that period, but remained at ≥ 3 meq/100 mL juice.

EVALUATING ANTIBROWNING SOLUTIONS. The optimum antibrowning agent in our experiments was the combination of 10% L-ascorbic acid and 2% KCl (pH 2.3) (Table 3); this mixture caused no apparent damage to the cut surfaces of the pears. Likewise, taste testers for wedges treated with this solution reported little or no sourness or saltiness after the fruit was held at 30 °F for 24 h.

Gorny et al. (1998) has shown that a combination of 2% ascorbic acid and 1% calcium lactate, applied as a dip for 1 min, is the most effective treatment for reducing the risk of browning in pear discs. Other diversified antibrowning solutions have been developed by other researchers claiming the effectiveness of controlling surface browning as well as extending shelf life of the fresh-cut pear wedges (Dong, et al., 2000; Sapers and Milles, 1998). In our study, we intend to develop a simple and effective antibrowning solution that is easy to prepare with the lowest cost for commercial practice. The use of potassium salt in our study was intended to increase the effect on antimicrobial growth as well as suppress the browning reaction on the cut surface of pear wedges. Sapers and Miller (1998) have used a 0.25% sodium chloride pretreatment on pear wedges to inhibit the browning reaction before applying their browning-inhibitor dip. Colloquially, potassium

Table 3. pH values and surface injuries recorded for fruit wedges treated with various combinations of L-ascorbic acid (C) and potassium chloride (KCl). Wedges were dipped in the selected mixture for 30 s, then stored at 30 °F (-1 °C) for 14 d; clear = no surface injury; slight = edges discolored; severe = discoloration on the flesh and edge of each wedge.

KCl (%)	C (%)				
	1	5	10	15	20
2	2.734 Clear	2.538 Clear	2.321 Clear	2.115 Slight	2.072 Severe
4	2.711 Clear	2.513 Clear	2.308 Slight	2.097 Severe	2.024 Severe
6	2.700 Slight	2.502 Slight	2.271 Severe	2.076 Severe	2.002 Severe

Table 4. Evaluation of dessert quality and surface-browning of fresh-cut 'd'Anjou' fruit wedges after being held at 30 °F (−1 °C) or 35 °F (2 °C) for 7 or 14 d². Fruit were ripened at 68 °F (20 °C) for 5 d, then used for the fresh-cut process. Ratings in each category are the range between highest and lowest score, as determined by the authors.

Temp (°F)	Day	Dessert quality (score 1–9)	Browning discoloration (score 1–9)
30	7	7.8–8.4	8.5–8.7
	14	7.6–8.4	7.8–8.2
35	7	8.0–8.6	8.2–8.7
	14	6.2–7.0	5.1–6.3

²Pears had previously been stored in a commercial, controlled-atmosphere room for 8 months before being purchased from the Duckwall-Pooley Fruit Company, Odell, Oregon, on 13 Apr. 2001.

chloride is probably preferred to sodium chloride by consumers who may wish to restrict the level of sodium salt in their diets. Although calcium salt reportedly minimizes the loss of firmness in fresh-cut fruit (Gorny et al., 1998, 2000; Rosen and Kader, 1989; Sapers and Miller, 1998), we have found that it is preferable to allow 'd'Anjou' wedges (FF of 6 lb) to soften gradually so as to improve overall dessert quality when this product is kept either on the retail shelf at 35 °F (2 °C) or on ice at 32 °F (0.0 °C) during a typical 14-d marketing period (unpublished results).

In developing the most effective antibrowning agent for our pear slices, we assumed that the solution with the lowest pH and the highest KCl concentration would also be the best at inhibiting microbial growth, as long as it did not adversely affect taste or cause damage to the cut surfaces. Pathogen outbreaks associated with newly harvested or fresh-cut produce have recently received much attention (Howard and Gonzalez, 2001). However, the subject of food safety is beyond the scope of this study. Nevertheless, whether the combination of high concentrations of L-ascorbic acid and KCl effectively suppresses the microbial growth must be further investigated.

FRESH-CUT SLICING PROCEDURES.

Although the methods of inverse cutting and submerged cutting prevented the fruit from being exposed to air during the slicing process, neither was easy to perform manually. However, both methods probably could be integrated into an automated fresh-cut operation. The method of pouring the antibrowning solution onto the incision was the easiest and most convenient procedure, and did not allow the pears to make direct contact with the

air during manual cutting. Therefore, this third method was used during the rest of our experimentation here.

DETERMINING THE SHELF LIFE OF FRESH-CUT RIPENED 'D'ANJOU' SLICES.

After the softened wedges (FF of 5 to 7 lb; dessert quality of 5.6) were held for 7 d at either 30 or 35 °F, their overall quality was recorded as having improved to 8.1 and 8.3, respectively (Table 4). By day 14, quality had not changed for fruit held at 30 °F, but it did decrease to a score of 6.6 for the, now-overripened, wedges held at 35 °F. At day 7, the level of discoloration was rated at 7 (very good) or above for fruit held at either 30 or 35 °F; by day 14, this value had gone below 7 only for wedges stored at 35 °F. Based on

these results, we suggest that the acceptable quality of 'd'Anjou' wedges can be maintained for 14 d when stored at 30 °F, or for 7 d if held at 35 °F. Because the ultimate purpose in providing attractively packaged, fresh-cut pears is to stimulate their purchase, any attempts to further extend their shelf life become meaningless.

The edge between the cut surface and the skin was most sensitive to the risk of browning; the untrimmed seed cavities at the centers of the wedges also showed slight discoloration. Therefore, we recommend that these seed cavities be removed during the slicing process. Regardless of the holding temperature, the cut surfaces had less sheen and gloss along with a more abrasive surface texture after 14 d, an observation also reported by Gorny et al. (2000). However, this dull appearance did not affect overall dessert quality. In fact, if processors were to incorporate shredded cheese, cottage cheese, or yogurt into their packaging (as described in the Introduction and below), this dullness might become less noticeable.

CONTAINER DESIGN FOR FRESH-CUT 'D'ANJOU' SLICES. The prototype container, with eight compartments, made packaging quick and easy. The tight, perforated lid also provided the

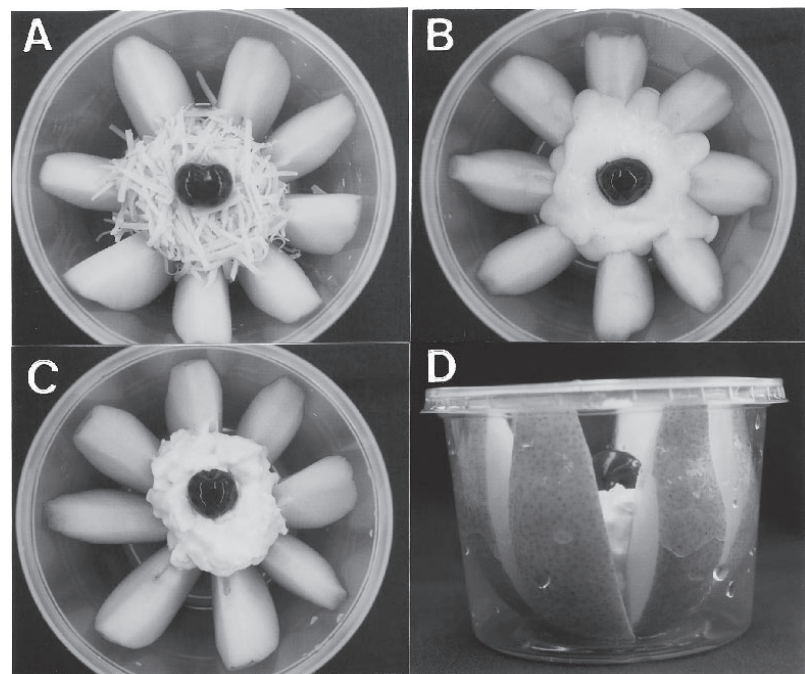


Fig. 5. Top view of eight wedges cut from an individual fruit that were arranged in the prototype container to form an attractive lotus-flower shape. Extra food items include (A) a scoop of shredded cheese, (B) yogurt, or (C) cottage cheese; which are added to the center of the arrangement and topped with a red maraschino cherry. (D) side view of the arrangement shown in C.

best air exchange for maintaining the freshness of fresh-cut pear wedges on the retail market. Unlike other pear cultivars (e.g., Bartlett, Bosc, and Comice) that develop strong aromas upon ripening, 'd'Anjou' pears have a unique, gentle scent. Therefore, arranging the wedges in an attractive lotus-flower shape and, perhaps, adding other decorative foods could also increase this product's desirability as a flavorful snack or dessert item (Fig. 5).

The proper range in size for an individual 'd'Anjou' pear for fresh-cut purpose is 80 to 110 fruit per 44-lb box. After its core is removed [approximate net weight 1.1 oz (29 g)], the average net weight of eight wedges is about 7.7 oz (218 g), 6.7 oz (190 g), 6.0 oz (170 g), or 5.4 oz (153 g) for fruit sizes of 80, 90, 100, or 110, respectively. By incorporating another food item into the container, the net weight can easily be standardized to 10.0 oz (283 g) for fruit sizes 80 and 90, or to 8.0 oz (227 g) for sizes 100 and 110. We must caution, however, that before commercializing such an enhanced product, one must assess the impact of adding cheese or yogurt with regard to microbial safety.

Conclusions

Because the consumer's first impression is crucial when selecting fruit for purchase, we propose that fresh-cut 'd'Anjou' products are properly ripened and most attractive when flesh firmness decreases to between 7 lb (3.2 kg) and 5 lb (2.3 kg). In this study, we found that the optimum antibrowning agent was a combination of 10% L-ascorbic acid and 2% KCl (pH 2.3). This mixture caused no apparent damage to the cut surfaces. Likewise, taste testers for the wedges treated with this solution reported little or no sourness or saltiness after the fruit was held at 30 °F for 24 h.

Both methods of inverse cutting and submerged cutting protected our pear slices from exposure to air, but neither slicing procedure was easy to

perform manually. In contrast, pouring the antibrowning solution onto the incision was the simplest and most convenient method, and prevented the wedges from making direct contact with the air during the cutting process.

At day 7, the level of discoloration was rated as very good (7+) for fruit held at either 30 or 35 °F. By day 14, however, wedges that were stored at 35 °F had a rating below 7. Therefore, we suggest that 'd'Anjou' wedges of acceptable quality can have an adequate shelf life of 14 d if stored at 30 °F or 7 d at 35 °F. Because the seed cavities were most sensitive to browning, we recommend that they be trimmed during the slicing process. In addition, discoloration along the cut edges might be less obvious if packagers were to incorporate shredded cheese, cottage cheese, or yogurt into the packaging.

The prototype container introduced here has eight compartments for individual wedges, which makes market presentation quick, easy, and attractive. Its tight, perforated lid also ensures the best air exchange. Our design allows the fruit to be arranged in the shape of a lotus flower. To further enhance the appearance and desirability of fresh-cut pear slices as a convenient, healthy snack or dessert, we suggest adding other decorative food items within the container.

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