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Air Shipment of 'Navaho' Blackberry Fruit to Europe is Feasible

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Currently, about 60% of blackberry fruit (*Rubus* spp.) production in the eastern United States is pick-your-own and most of the remainder is marketed locally. With a 50% projected expansion of blackberry plantings (Clark, 1992), there is a need for new market development. Blackberry fruit are being shipped by air to the United States and Europe from Guatemala, Chile, and Costa Rica, and within Europe from Italy and Spain. The European market windows for blackberries are from late May to late June, and from August to November. Europe is a potential market for blackberries produced in the southern United States, as the blackberry harvest season is from early May to mid-July in this region.

Blackberries have a very short shelf life (Hardenburg et al., 1986). Fruit firmness at harvest influences blackberry shelf life, as soft fruit are more easily damaged during harvest and handling, and are more susceptible to pathogen infection (Clark, 1992). We have found that fruit of 'Navaho', a thornless erect blackberry, have excellent shelf life (Perkins-Veazie et al., 1996). We therefore wanted to evaluate the potential of this cultivar for export to Europe.

Six flats of fruit, each containing twelve, 250-g vented clear plastic clamshell containers (#5050-175; Agri Pac, Minneapolis) containing 40 berries each were harvested from a commercial planting in Ada, Okla., between 7 and 10 a.m. on 27 June and 7 July 1994. Two flats of blackberries were transported on ice (=1 h) to the U.S. Dept. of Agriculture-Agricultural Research Service (USDA-ARS)

research laboratory in Lane, Okla. Remaining clamshell containers were placed into picnic coolers containing ice and cooled from the ambient air temperature of 30 to 35 °C at harvest to 7 to 10 °C during the 3-h transport by van to the Dallas-Fort Worth International Airport. A broker at the airport packed four flats of berries into styrofoam containers containing 10 kg ice substitute (Blue Ice; Rubbermaid, Wooster, Ohio), 12 kg dry ice, and a 7-d recording thermometer (Marathon Temperature Recorder Co., Modesto, Calif.).

Fruit were airfreighted to Rotterdam, The Netherlands; received by a broker; and transferred to the USDA-ARS European Marketing Research Center in Rotterdam. The temperature range during air transit was -0.5 to 1 °C. Twenty-four clamshells per shipment were evaluated for market suitability by the broker and 12 clamshells were damaged in each shipment. Of the remainder, four clamshells were evaluated upon arrival, four evaluated after 7 d storage at 2 °C, and four after 7 d storage at 2 °C followed by 2 d storage at ambient temperature (=20 °C). Fruit transported to Lane, Okla., were stored similarly as those sent to Europe. Following the 2 weeks of storage, percent mass loss was determined and berries were individually rated for decay and leakiness. Percent marketable fruit after storage was calculated by subtracting the percent of leaky berries from 100%. Berries were gently rolled on a white paper towel and were considered "leaky" if the towel was juice-stained.

Ratings were averaged among clamshells, mass loss was calculated for each clamshell,

and clamshells were the replications. Analysis of variance was used with a factorial combination of location and storage interval. Means were separated by the Ryan-Einot-Gabriel-Welsch multiple F test (REGWF; Schlotzhauer and Littell, 1987), at $P \leq 0.05$.

Fruit quality did not differ after 7 d between exported fruit and fruit held at Lane as long as berries were held constantly at 2 °C upon arrival (Table 1). Holding fruit 2 days at 20 °C following cold storage accelerated berry mass loss at both destinations. In comparison with fruit held at Lane, decayed and leaky fruit were more common and the percent marketable fruit was lower in exported fruit after 2 d at 20 °C following cold storage. Increased handling and temperature fluctuations during export apparently accelerated deterioration of shipped berries after storage at 20 °C.

'Navaho' fruit sent on the first shipment were considered highly acceptable by the fruit broker, being firm and sweet (10% soluble solids concentration), and they compared favorably with shipments from Spain and Italy. Fruit damage occurred when the clamshells opened during transit and the fruit were crushed. In the second shipment, fruit were sent on a Friday and were left at air temperature (20 °C) for ≈30 h after arrival. The fruit broker considered the majority of the fruit to be too soft to be marketable.

The unusually good storage life of 'Navaho' fruit indicates suitability for export. The accelerated decay, leakage, and weight loss of fruit shipped to Europe following storage at 20 °C illustrates that proper temperature control, handling, and packaging during all phases of transit and distribution will be essential for successful marketing of berries to Europe from the United States.

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¹Retired.

Table 1. Comparison of the postharvest quality of 'Navaho' blackberries harvested 27 June and 7 July 1994 that were stored at Lane, Okla. (L), or air shipped to Rotterdam, The Netherlands (N).¹

Storage interval ²	Days from harvest	Quality attribute					
		Mass loss (%)		Decay (%)		Marketable fruit (%)	
		L	N	L	N	L	N
Arrival	4	1.1 a	0.9 a	0 a	0 a	96 a	95 a
7 d at 2 °C	11	2.9 b	2.6 b	6 a	2 a	91 a	90 a
7 d at 2 °C + 2 d at 20 °C	13	4.7 c	6.5 c*	14 a	43 b*	87 a	32 b*

¹Values represent means of eight clamshell containers (four clamshells per shipping date) (320 berries) separated by REGWF test, within location. Significance between locations is indicated by *. Marketable fruit = 100 - percent leaky fruit.

²Storage interval significant, $P \leq 0.05$.