# Relationship between Fruit Color (ripening) and Shelf Life of Cranberries: Physiological and Anatomical Explanation

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## Introduction

In general it is agreed that ripened cranberries store better. However no data on this aspect are currently available. This study was conducted with the **following objectives** in mind:

1. To determine qualitative relationship between fruit color (ripening) and shelf life.
2. To determine the physiological properties of the fruit (ethylene production, respiration) that might explain the observed relationship between fruit color and shelf life.
3. To determine the anatomical properties of the fruit (fruit cuticle thickness, wax, sealing of the calyx end) that might explain the observed relationship between fruit color and shelf life.

The fruit develops color in the outer two cell layers in response to low temperatures and incident light. Berries at the top of the canopy generally develop full red color whereas fruits in the lower part of the canopy (especially under dense canopies) can remain white (snow balls) even at harvest time. This is especially true for Wisconsin grown cranberries. Wet harvested cranberries are stored for l-2 months and sold at Thanksgiving and Christmas time. We investigated if the storage quality of fruit is dependent on ripening state.

## General Methodology

Wet harvested cranberries (cultivar Stevens) were sorted into four different ripening stages along with size of berries: dark red ( 55-59/100 g), light red ( 57-65/100 g), blush (61-68/100 g) and white ( 63-69/100 g). Berries were rated for quality after 4 and 7 weeks of storage. In addition, fruit respiration ( $CO_2$ ) and ethylene production, as well as anthocyanin content were measured after 4 weeks of storage.

## Results

There were large differences in anthocyanin content among the groups selected (Figure 1). About four times more anthocyanin accumulation was observed in dark red berries as compared to light red berries.

**The storage quality of the fruit was significantly effected by the ripening stage at the time of storage (Figure 2).** At the end of the 7 weeks of storage the percent marketable berries were 82, 75, 63 and 56 in dark red, light red, blush and white group respectively. Between 4 to 7 weeks of storage only 6% of the dark red berries spoiled as compared to 17% of white berries spoiled in the same period.

**A higher respiration rate appears to be associated with poor shelf life (Figure 3).** Carbondioxide production by the fruit was doubled in the white-berries as compared to dark red berries.

Rate of ethylene production by the fruit did not change significantly among the four groups (Figure 4). It is interesting to note that ethylene production by the fruit is much lower than respiration rate.

There were significant differences in total soluble solids (brix) content of the four groups. **The berries that had higher anthocyanin content, had also had higher soluble solids measured (Figure 5).**

Our result also show that cranberry fruit has variable cuticle thickness at different ripening stage. We found that **ripened fruit had thicker cuticle.** Cuticle thickness of white berries was about 1.62 µm, and of dark red berries was 2.33 µm. (Figure 6).

Although there are no data available at this point, some of our recent observations suggest that dark red berries have more wax accumulation on the berry surface and at the calyx end of the fruit. The observations suggest that during ripening fruit surface is more sealed off from the environment which might help to reduce the penetration of organism in the fruit during wet harvest. These observations may help to explain better shelf life of ripened fruit.

## Conclusion

Our study showed that ripened cranberries have better storage life and higher quality. As fruit ripens, rate of anthocyanin accumulation increases rapidly. Our results show that low fruit respiration and thicker cuticle contribute to better shelf life of ripened fruit.

## Acknowledgments

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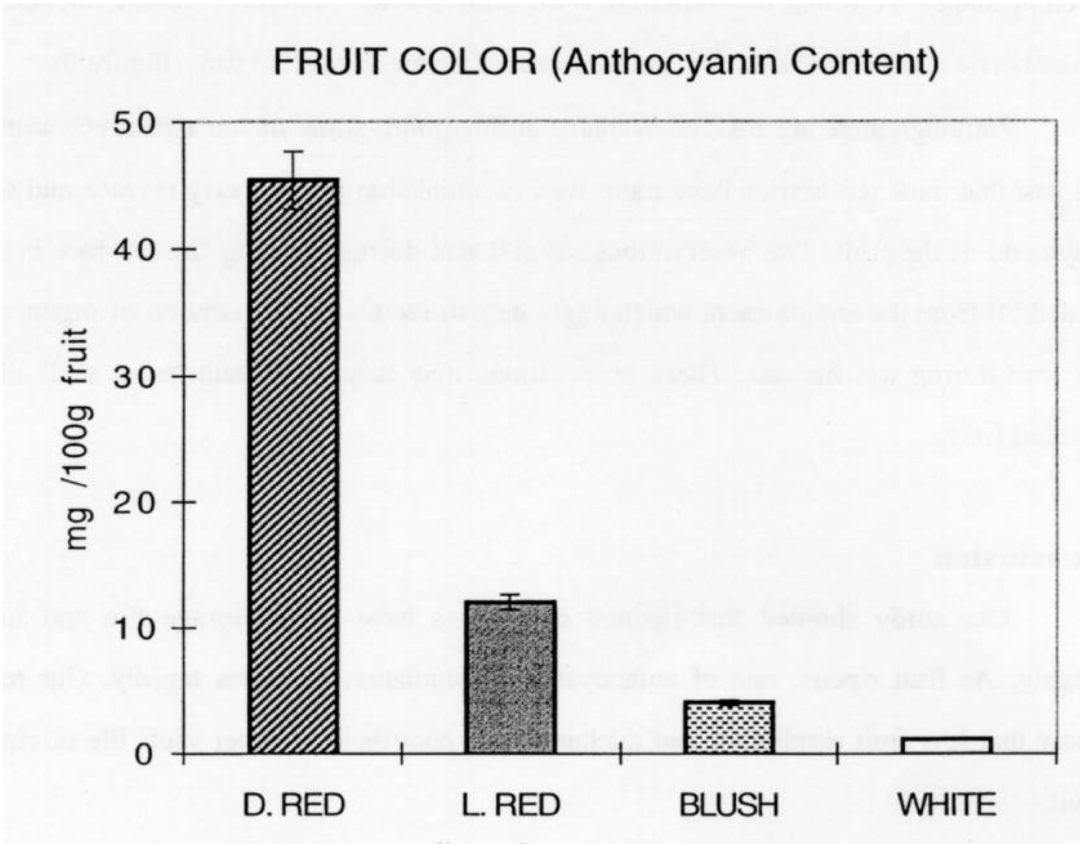


Figure 1: Anthocyanin (color) contents of cranberry fruit as related to ripening stage. Wet harvested cranberry (cultivar Stevens) fruits were sorted in four different categories depending upon the fruit color. For anthocyanin contents 100 g. of fruit were ground in 1.5 N HC1 and ethanol (15:85 v/v) buffer solution. Anthocyanin contents were quantified with a spectrophotometer (535 nm). Data are mean ±SE of three separate measurements. D.Red:dark red, L.Red:light red.

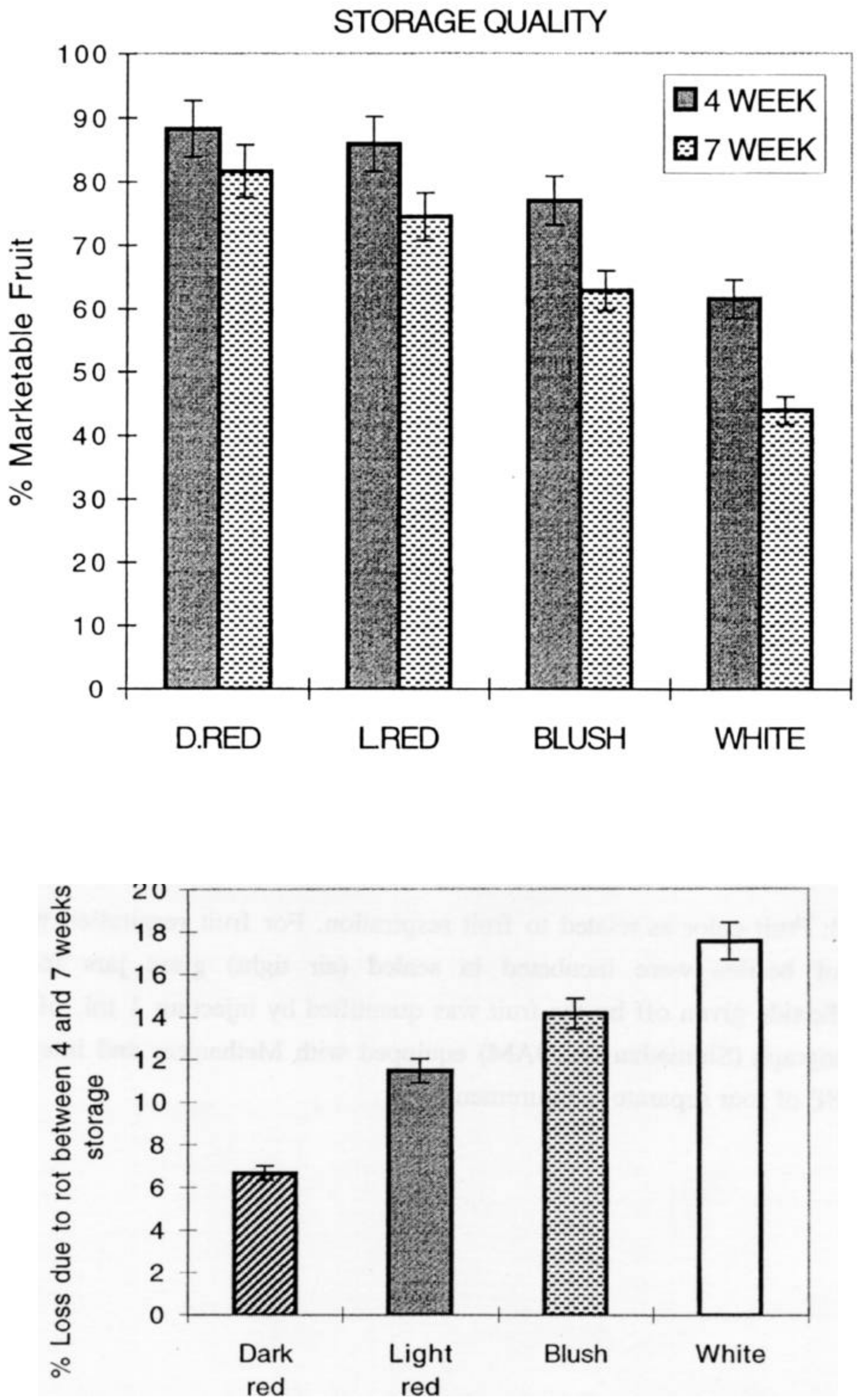


Figure 2: Impact of fruit color on shelf life. Fruits were stored in a commercial cold storage for 4 and 7 weeks and evaluated for marketable quality. Data are mean ±SE of five separate measurements.

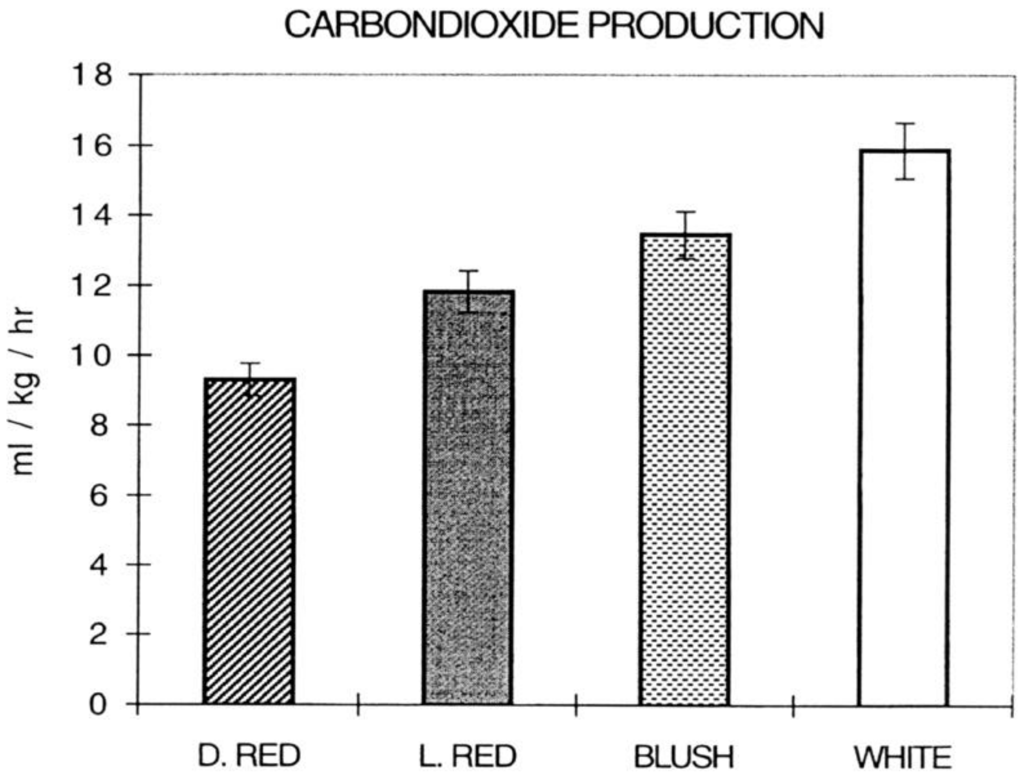


Figure 3: Fruit color as related to fruit respiration. For fruit respiration measurement 50 grams of berries were incubated in sealed (air tight) glass jars for 30 minutes. Carbondioxide given off by the fruit was quantified by injecting 1 ml. of gas into a gas chromatograph (Shimadzu GC-9AM) equipped with Methanizer and integrator. Data are mean ±SE of four separate measurements.

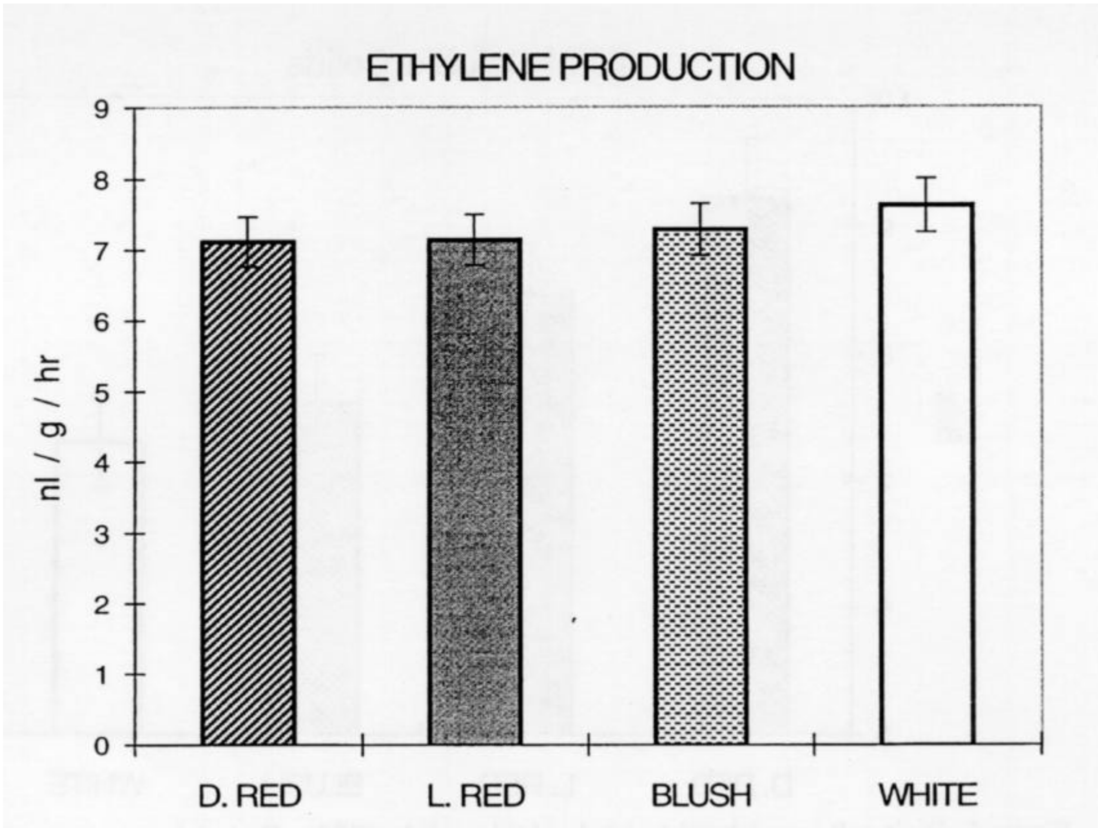


Figure 4: Fruit color as related to ethylene production by fruit. For ethylene measurement 50 grams of berries were incubated in sealed (air tight) glass jars for 24 hours. Ethylene given off by the fruit was quantified by injecting 1 ml. of gas into a gas chromatograph (Shimadzu GC-9AM) equipped with flame ionization detector and integrator. Data are mean ±SE of four separate measurements.

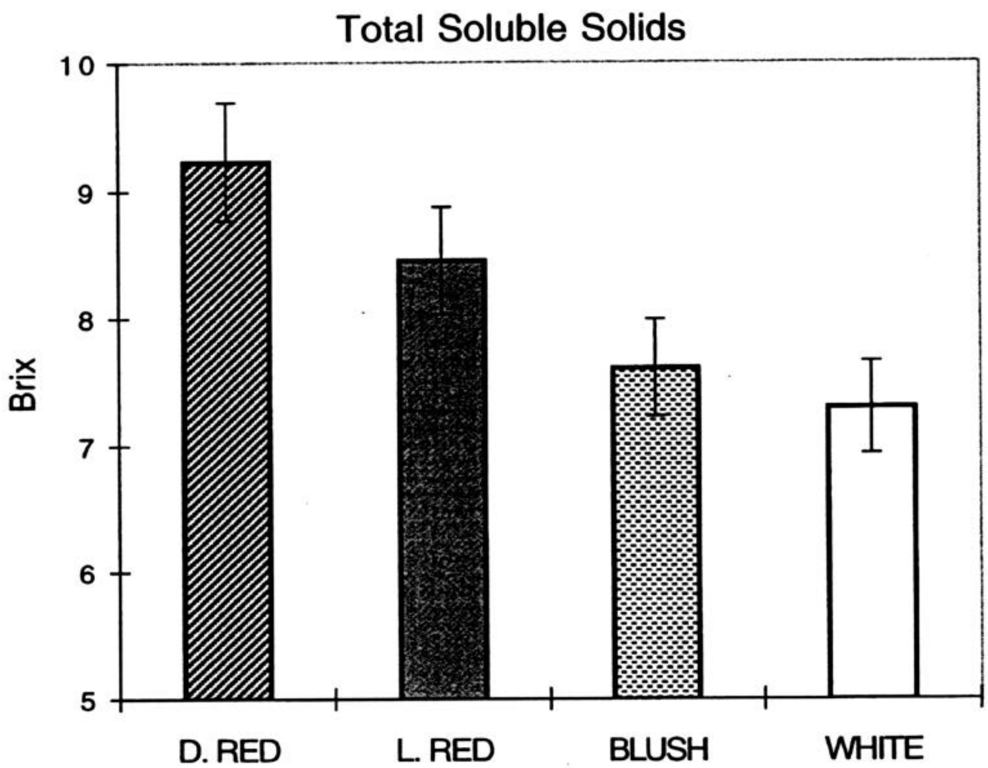


Figure 5: Fruit color as related to total soluble solids (TSS). Fruit juice was extracted and TSS was measured as brix by using hand refracrometer. Data are mean ±SE of seven separate measurements.

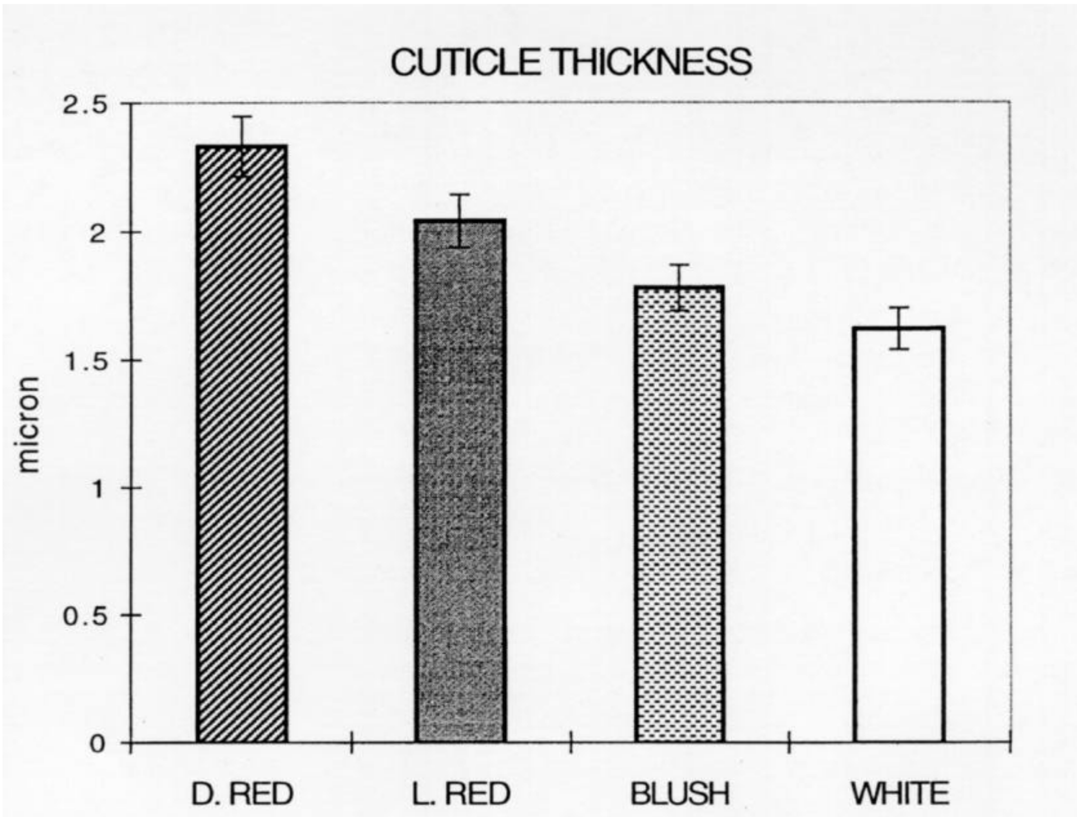


Figure 6: Fruit color as related to fruit cuticle thickness. Fruit cross section (150 µm) were made using a vibrotome. Cuticle was measured with the help of a light microscope equipped with a video output. Data are mean ±SE of twenty separate measurements.