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Short communication

Respiration rate of fruit flesh from red and green sides of 'Cortland' apples[1]

V. G. SHUTAK and J. C. HAPITAN, Jr.[2]

Rhode Island Agricultural Experiment Station, University of R. I., Kingston, Rhode Island, U. S. A.

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Respiration rate of apple flesh from red and green side of 'Cortland' apples was measured using Gilson respirometer. Respiration from red side was greater for both pre and post climacteric fruit. Flesh from the red side was also higher in soluble solids, fresh weight and dry weight.

Numerous physical and chemical differences have been reported to exist between the red and the green side of an apple (*1*). However, the authors were unable to find any reports comparing respiration rates of the apple flesh from the green and the red side of the fruit.

'Cortland' apples were harvested on September 27, 1967 and placed in cold storage at 0±1°C. For each determination, fruits were selected in storage with a diameter of 6.4 to 7.0 cm and with 35 to 60% red color and removed to the ripening room at 21±1°C 24 hr prior to respiration measurements. Fruits remained in the ripening room until used. The respiration rate of 'Cortland' apple flesh was measured manometrically, using the Gilson differential respirometer (Gilson Medical Electronics).

Fruit was transversely cut into two equal parts. A cork borer with a diameter of 1.3 cm was used to cut out one cylinder of flesh from the green and one from the red side from each half of every apple.

A disc near the top of the removed cylinder, which was nearer the center of the fruit, was cut off with a double knife made of two razor blades welded together 0.4 cm apart. This produced a sample disc of 2.704 cm^3. ARCHBOLD and BARKER (*2*) found the amount of total sugars in the apple increased from the stem to calyx end. Thus, it was essential to select the sample as near the center of the fruit as possible to minimize variations present within the apple.

To prevent dehydration of the tissue during preparation, the cylinders and the discs were floated in distilled water. All discs from the red and the green side were placed in separate beakers and later removed at random for analysis.

After the discs were prepared, 4 were placed in each reaction vessel containing 0.2 ml of 20% KOH in the center well and 2.5 ml of distilled water on the bottom of the flask. The rate of respiration was measured for 2 hr after an initial 30 min equilibration and is expressed as μl $O_2/cm^3/hr$. All determinations

[1] Contribution No. 1283 of the Rhode Island Agricultural Experiment Station.

[2] Present address : Department of Agronomy, U. P. College of Agriculture, College Laguna, Philippines.

were made at 28°C.

The majority of fruit used in these investigations was from untreated trees; however, fruit from trees sprayed with either 2000 or 3000 ppm of succinic acid 2,2-dimethyl hydrazide (Alar) on July 24, 1967 was also included, to determine whether Alar alters the relationship of the rate of respiration between the red and the green side of the fruit.

Soluble solids, fresh and dry weights of the discs from the red and the green side of the fruit were determined on 25 apples. The procedure for selecting samples was similar to that used for respiration studies. Fresh and dry weights were obtained from 5 groups of 5 discs each. After fresh weight was recorded, samples were dried at 55°C for 24 hr and at 105°C for the next 24 hr. Soluble solids were measured with a hand refractometer (No. 43790 ATAGI, Tokyo). Data were analyzed by a 2 way analysis of variance (*4*). The DUNCAN Multiple Range Test was used for mean separations at the 5% level of probability (*5*).

Fruit for the first series of respiration measurements was removed from storage on October 11 and placed in the ripening room. Determinations were

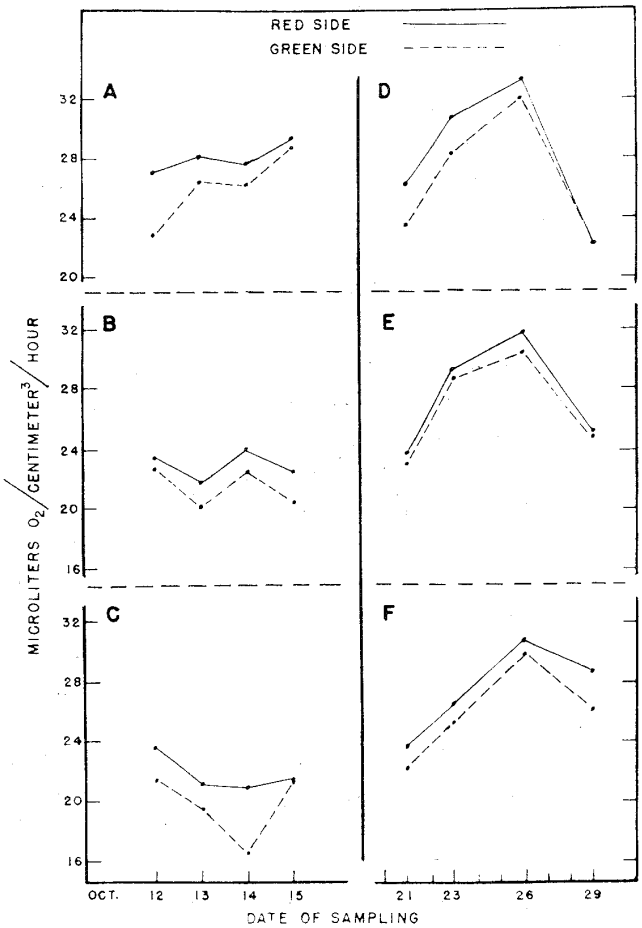

Fig. 1. Respiration rate of fruit flesh of 'Cortland' apples. Fruit was selected from unsprayed trees (A and D) and from trees sprayed with Alar at 2000 ppm (B and E) and 3000 ppm (C and F).

Table 1
Pre- and post-climacteric respiration rate of fruit flesh from the red and green side of 'Cortland' apples ($\mu l\ O_2/cm^3/hr$)

Fruit sample	Mean respiration rate[1]	
	October 20	December 2
Red side	24.07[a]	35.27[a]
Green side	23.13[b]	33.59[b]

[1] Means in the same column followed by the same letter are not significantly different at 5% level.

started on October 12 and continued daily until October 15, 1967. Results shown in Fig. 1 A, B and C indicate that the respiration rate of samples from the red side of the fruit was higher and that Alar treatment did not appreciably alter these differences.

Since physical limitations of the respirometer prevented determinations of sufficient number of samples for statistical analysis, a second series of determinations were made on untreated fruit only. Seven apples were removed from storage on October 19 and measurements of their respiration rate were made on October 20. Four sections from the red and the green side of each fruit were taken. Results presented in Table 1 show that the difference in the rates of respiration between the two sides of the fruit was highly significant.

Another sample of fruit was removed from storage on October 20 and respiration measurements were started on October 21, Fig. 1 D, E and F. Results were quite similar to those obtained in the first determination except that the magnitude of the respiration curve was greater. The rate of respiration for the red side was again consistently higher than from the green, regardless if the fruit was from Alar sprayed trees or not.

To determine if significant difference between the green and the red side of the fruit exists after climacteric, 7 untreated post climacteric (*1*) fruits were removed from storage on December 1 and respiration rate was measured the next day. Results are presented in Table 1. Rate of respiration of the red side of the apple was again significantly higher than that of the green side. The data presented leaves little doubt that the fruit flesh from the red side of 'Cortland' apples, if measured on a volume basis, respires at a higher rate than the flesh from the green side. It should be noted that, although the selection of samples was made in relation to the outside color of the apple, the flesh used was a considerable distance from the cuticle of the fruit. The vascular bundle was always near the center of the sample; however, its location varied from one fruit to another. In general, it was found to be between 1.5 and 2.5 cm from the outer edge of the fruit. Our results indicate that the respiration rate of the flesh is influenced to a considerable depth by the color of the skin.

It has been reported (*3*) that there are more total sugars on the red side of Jonathan apple. To determine if a similar relationship exists in soluble solids in 'Cortland', 25 apples were sampled on December 1. Samples were taken as for respiration measurements, and soluble solids were determined on the red and

Table 2
Soluble solids content and fresh and dry weight of fruit flesh from the red and green side of 'Cortland' apples (December 1, 1968)

Sample	Soluble solids (%)	Fresh weight (g)	Dry weight (g)
Red side	11.91[a]*	2.888[a]	0.320[a]
Green side	10.96[b]	2.692[b]	0.298[b]

* Means in the same column followed by the same letter are not significanty different at 5% level.

green side of each fruit. The results presented in Table 2 show significantly higher soluble solids on the red side of the fruit. Soluble solids in the apple are mostly sugars (*1*) and thus may very well account for the differences in respiration rate by providing more abundant substrate.

The same apples were used for determinations of fresh and dry weight. Sections from the red side were heavier than the sections from the green side as shown in Table 2.

These data show that whenever apple flesh is used for any comparative studies, samples should be selected not only according to their relative orientation in the fruit but also in relation to the outside color. They also suggest that when a whole fruit is used in respiration determinations, the red color on individual fruits should be taken into consideration. It is realized that the red coloration in some cases may be related to maturity, which could further complicate interpretations of experimental results.

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