

## SHORT COMMUNICATIONS

### RELATION BETWEEN LOW-TEMPERATURE BREAKDOWN AND THE VOLATILES GIVEN OFF BY INDIVIDUAL APPLES\*

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Low-temperature breakdown is a physiological disorder of apples which severely limits the storage life of susceptible varieties. Kidd and West (1927) considered the disorder to be caused by an alteration in metabolism of the fruit below a certain critical temperature rather than due to senescence.

Overholser, Winkler, and Jacob (1923) reported that breakdown was reduced by increasing the rate of air circulation over the fruit and suggested that this treatment accelerated evaporation of some toxic volatile compound(s) from the fruit. Recently Hulme, Smith, and Woollorton (1964) suggested that interference with the acids of the Krebs' cycle, leading to an accumulation of oxaloacetic acid, was responsible for breakdown, but Wills and McGlasson (1968) found no differences in the levels of the Krebs' cycle acids that could be associated with differences in breakdown.

Australian workers found that the incidence of breakdown was reduced by increasing the rate of loss of water from the fruit (Scott *et al.* 1964; Martin, Lewis, and Cerny 1967; Scott and Roberts 1967). Wills (1968) studied the volatiles given off by apples stored under conditions promoting different rates of water loss from the fruit. He found that values of the ratios n-butanol-n-butyl acetate, isoamyl alcohol-isoamyl acetate, and n-hexanol-n-hexyl acetate decreased as the rate of water loss increased.

Apples selected on external features (e.g. size, colour) to give a sample as uniform as possible still vary considerably in susceptibility to physiological disorders (Hall and Cellier 1966). In the present work apples were stored under conditions of low water loss. The variability in evolution of alcohols and esters of individual fruits was studied to determine whether differences in the ratio of alcohol to acetate ester could be related to the level of breakdown.

#### *Materials and Methods*

Eighty apples that had been graded visually for uniformity were stored at 30°F in boxes lined with polyethylene film. After 6 months, each apple was placed in a glass jar and air of 75%

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relative humidity was passed over each fruit at 1 litre/hr. The volatiles were collected for 48 hr by inserting a cold trap (ethanol-dry ice) in the air lines leaving the jars.

The trapped material was analysed by gas chromatography with an FFAP (Wilkens-Varian Aerograph) column as described by Wills (1968). After the volatiles had been collected, the fruits were transferred to 68°F and examined 7 days later for breakdown.

The ratios of the amounts of n-butanol, isoamyl alcohol, and n-hexanol to their corresponding acetate esters and their reciprocals (i.e. ester/alcohol) were calculated. The 80 values for each ratio were arranged in decreasing order of magnitude and divided into sets of about 10 consecutive values. Mean values of the ratios in each set were calculated and the percentage of fruit in each set with breakdown was also calculated. Correlations were calculated between percentage of apples with breakdown (in angles) and mean values of the ratios.

### Results and Discussion

The values of the ester/alcohol ratio showed a more linear relation with breakdown than did those of the alcohol/ester ratio and the former were used in the statistical analysis. The mean values of the ester/alcohol ratio and corresponding levels of breakdown are shown in Figure 1.

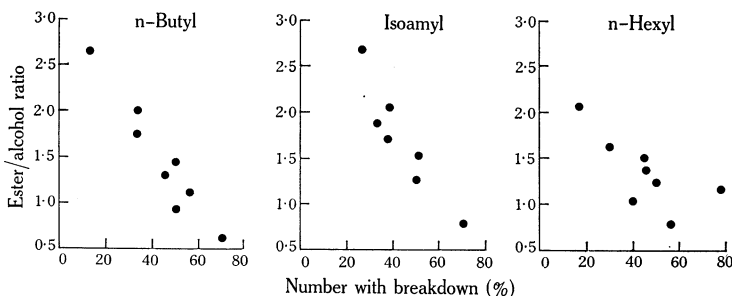


Fig. 1.—Mean values of acetate ester/alcohol ratios correlated with percentage of apples with breakdown.

The correlation coefficients between breakdown and the ratios were  $-0.96$ ,  $-0.94$ , and  $-0.76$  for n-butyl acetate-n-butanol, isoamyl acetate-isoamyl alcohol, and n-hexyl acetate-n-hexanol respectively. All correlation coefficients were highly significant ( $P < 0.01$ ).

The correlation of the natural susceptibility of fruit to breakdown with ester/alcohol ratios during storage extends the work of Wills (1968) who examined a treatment known to affect breakdown. The measurement of ester/alcohol ratios could provide a convenient, non-destructive method for grading apples for susceptibility to breakdown before the first visual signs of the disorder appear.

Work is proceeding in this laboratory to determine if esters or their constituent parts cause breakdown.

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