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Changes in contents of important constituents during ripening of *Prunus cerasus* L., cv. 'Stevnsbär'

Modningsforløbet i Prunus cerasus L., cv. 'Stevnsbær'

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Summary

Changes in fruit weight, stone percentage, soluble solids, colour, acid, and cyanide content in fruit flesh, and cyanide content in fruit kernels were observed during the ripening period. Each of these components of fruit quality approach asymptotic values. Sprays of ethephon (250 ppm) applied at two stages of ripening did not significantly affect changes in fruit constituents during ripening, but reduced fruit removal force. It is concluded that early harvesting, which is possible with ethephon-sprays, should be avoided in order to obtain maximum quality for industrial processing purposes.

Key words: fruit quality, soluble solids, cyanide, ethephon.

Resumé

Ændringer i bærvægt, stenprocent og frugtkødets indhold af opløseligt tørstof (sukker), farve, syre og cyanid, samt kernernes indhold af cyanid blev fulgt under modningen. Alle de målte størrelser nærmer sig en asymptotisk værdi. Sprøjtning med ethephon på to tidspunkter i modningsperioden påvirkede ikke hastigheden i disse ændringer, men reducerede frugtretentionskraften. Det konkluderes, at 'Stevnsbær' bør høstes så sent som muligt for at opnå bedst mulig kvalitet til industrielle formål. Tidlig høst, som er mulig med ethephon-behandling, bør undgås.

Nøgleord: frugtkvalitet, opløseligt tørstof, farve, syre, cyanid, ethephon.

Introduction

The main sour cherry cultivar grown in Denmark is 'Stevnsbär', which has recently been described (*Vittrup Christensen* 1976). The fruits are almost exclusively used for industrial production of wine, liqueur, and preserves.

The popularity of this cultivar is due to several reasons: high content of sugar, acid, and colour, good resistance against pests, and good adaptability to mechanical harvesting.

However, uneven ripening is often a problem. It was shown proviously that ethephon applied 1–2 weeks before harvest accellerates abscission and increases fruit removal in mechanical harvesting (*Grauslund* and *Stoyanov* 1971). Ethephon has been widely used for some years, but in 1975 the processing industry complained, that ethephon-sprayed trees yielded fruits with lower levels of soluble solids. An experiment carried out in 1976 to test this relationship showed no effect of ethephon on levels of soluble solids (*Christensen* 1976a). Since 1976 was an exceptionally warm and dry summer, the experiment was repeated in 1977. The result of the 1977-experiment is reported below together with the main results of the previous year.

Materials and methods

Treatments. Two blocks of 17 trees each were used in this experiment. The trees were 11 years old. One of the blocks was heavily pruned the proceeding winter, while the other was unpruned. In each block the following treatments were applied: 6 trees were sprayed with 250 ppm ethephon on July 25 (20 days before the predicted harvest date (*Vittrup Christensen* 1973), 4 trees were sprayed in the same way on August 4 (10 days before predicted harvest), and 7 trees were left as controls.

Sampling. Four representative branches (2 from each block) were sampled twice weekly from untreated trees from July 18 until August 29. Samples were taken in the same way from treated trees, starting on the day of spraying. All fruits on a branch were picked, so no selection according to ripeness (colour) took place.

Measurements. In each of the four replicates the following measurements were made:

1. Fruit fresh weight, average of 100 fruits.
2. Stone percentage, weight of stones in per cent of sample (400 g).
3. Soluble solids of fruit flesh, refractometric (400 g).
4. Acid content of fruit flesh, determined by titration in a 400 g sample, expressed as per cent citric acid.
5. Anthocyanines of fruit flesh, determined spectrophotometrically in an acidic methanolic extract. Content expressed as mg malvidinechloride (standard) per g fruit flesh (extinction coefficient $\sum = 32690$).
6. Cyanide in fruit flesh, determined with ion-selective electrode as ppm CN^- according to *Christensen* (1978).
7. Fresh weight of kernels, average of 25 kernels.
8. Cyanide in kernels, as ppm CN^-.
9. Fruit retention force, FRF, between fruit and pedicel in gram. Average of 25 fruits. (Hunter Spring, Model L-1000 M).

Statistical treatment of results

The experiment in 1976 (*Christensen* 1976a) showed that the relation between the content of a certain constituent and time was best fitted using an exponential equation.

$$\ln (P - A) = b_o + b_{n+1} \times d \qquad 1)$$

where P is the concentration of the constituent, and d is the number of days from the fruit picking date. A, b_o and b_{n+1} are constants.

As the results from both years showed a considerable difference in ripening stage among trees it was decided to determine the constants in equation 1 individually under the assumption that b_{n+1} are the same for all replicates, which seems to be a reasonable hypothesis. Our model 1) then can be formulated as follows:

$$\ln (P_{i,j} - A) = b_o \times_{o,j} + \sum_{i=1}^{i=n} b_i x_{i,j} + b_{n+1} d_{i,j} \qquad 2)$$

The subscript i refer to replicate number and j to the picking date number.

$x_{i,j}$ are 'dummy variables' having the following values

$$x_{i,j} = 1 \quad \text{for } i = j$$
$$x_{i,j} = 0 \quad \text{for } i \neq j$$
$$\text{with } x_{o,j} = 1 \quad \text{for all } j$$

The following quantities are calculated. The correlation coefficient R_1, the standard deviation $s(b_{n+1})$ and $s(b_o+b_i)$.

The correlation coefficient R measures how well the model fits to the results. The standard deviation $s(b_{n+1})$ is used to determine whether there are significant differences in ripening rate between treatments; $s(b_o+b_i)$ are used to indicate the differences in ripening stage at first picking date.

Measurements of FRF from six picking dates (August 4 till August 22) were subjected to analysis of variance.

Results

R was highly significant for all measurements of fruit constituents ($R > 0.93$, $n = 27$). Therefore, changes in the content of these substances are fairly well expressed by the proposed model.

These changes were not significantly affected by ethephon-treatments.

A significant effect of pruning was found on fruit weight and soluble solids. On the same date of picking pruned trees had higher fruit weight and lower levels of soluble solids.

Figures 1–4 show regression curves of fruit weight and all measured fruit constitutents as a

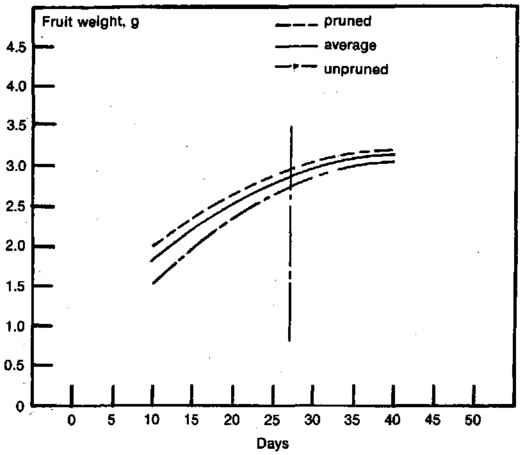

Figure 1. Regression line between average fruit weight and time of harvest. The vertical line in this and the following figures indicate predicted harvest date according to *Vittrup Christensen* (1973).
Regressionslinie for den gennemsnitlige bærvægt som funktion af plukketidspunktet. Den lodrette linie i denne og de følgende figurer angiver den prognosticerede høstdato efter Vittrup Christensen (1973).

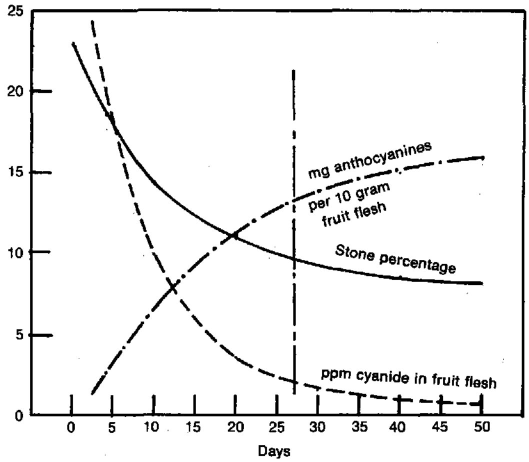

Figure 3. Contents of anthocyanines and cyanide, and stone percentage.
Farve- og cyanidindhold samt stenprocent.

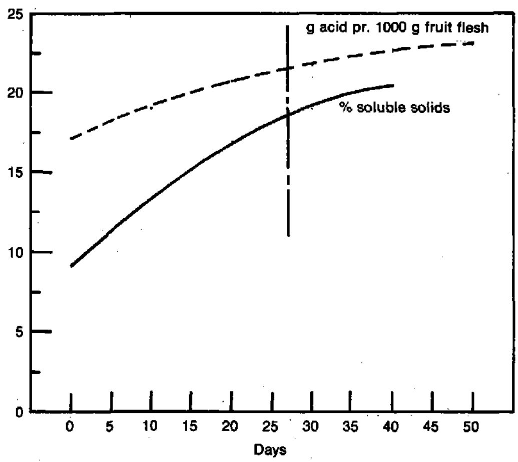

Figure 2. Per cent soluble solids and acid.
Procent opløseligt tørstof og syre.

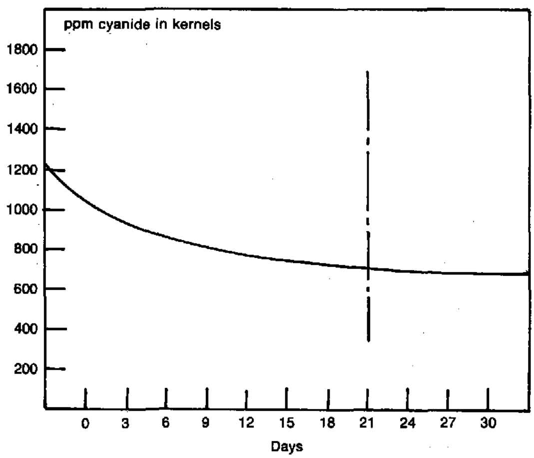

Figure 4. Cyanide in kernels.
Cyanidindholdet i kerner.

Table 1. Asymptotic values of fruit wright, stone percentage, and several constituents of 'Stevnsbär'-fruits
Asymptotiske værdier for frugtvægt, stenprocent og indhold af forskellige stoffer i 'Stevnsbær'-frugter

	1977	1976
Fruit fresh weight, g/fruit	3.1	2.2
Stone percentage	8.2	8.9
Content in fruit flesh:		
Soluble solids, %	Ca. 21	Ca. 24
Acid (as citric),%	2.35	2.28
Anthocyanines (as malvidine-chloride), mg/g	1.62	1.45
Cyanide, ppm CN^-	0.6	0.6
Content in fruit kernels:		
Cyanide, ppm CN^-	Ca. 600	–

function of time of picking. Asymptotic values are shown in *table 1.*

Changes in fruit retention force during the ripening period is shown in *figure 5.* 4–7 days after an ethephon-treatment FRF drops significantly below control, especially after the early spray.

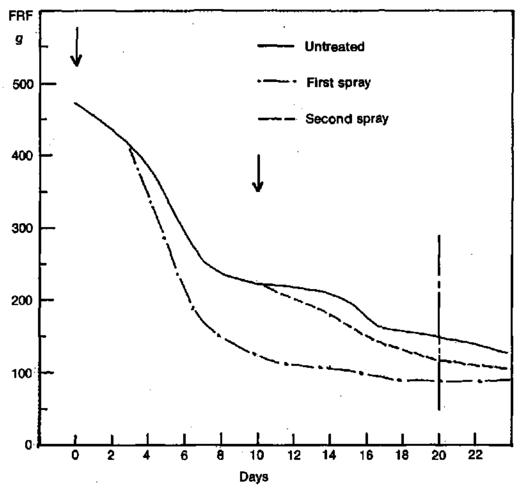

Figure 5. Fruit retention force of untreated and ethephon-treated fruits. Arrows indicate dates of ethephon application.
Frugtretentionskraften i ubehandlede og ethephon-behandlede frugter. Pilene angiver sprøjtetidspunkter.

Discussion

Fruit weight and concentration of soluble solids, acid, and anthocyanines all increase during the experimental period and approach asymptotic values. A drop in anthocyanines after full ripeness as shown by *Freytag* and *Blasse* (1957) was not found in the present experiment. Perhaps this drop is only to be expected when picking is postponed for three or more weeks beyond normal harvest time in the cultivar 'Stevnsbär'. Acid content may vary in a similar way.

Cyanide level decreases strongly during ripening and approaches zero. The drop in cyanide content is most likely due to a reaction between CN^- and monosaccharides as pointed out by *Christensen* (1976b, 1977b). Weight of stones was constant during the experimental period (0.26 g/stone). The same was true for weight of kernels (0.08 g/kernel).

Ethephon did not affect fruit growth or content of fruit constituents. This is in agreement with studies of other workers, who also found no or only very slight stimulation of ripening with ethephon in sour cherries (*Schumacher* and *Frankhauser* 1969, *Grauslund* and *Stoyanov* 1971, *Vitagliano* and *Edgerton* 1972, *Gil* and *Momberg* 1975, *Vatamanyuk* 1976). Apparently fruit growth and metabolism continue unaffected despite the very marked reduction in fruit removal

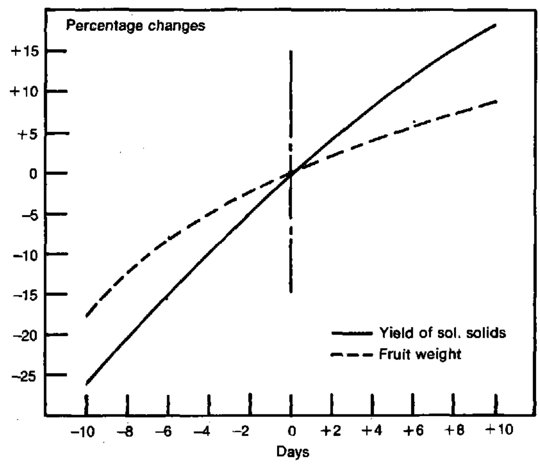

Figure 6. Changes in fruit weight and yield of soluble solids at different harvest dates in per cent of values at the predicted harvest day.
Procentvise ændringer i bærvægt og udbytte af refraktometertørstof ved fremskyndelse henholdsvis udsættelse af høsttidspunktet i forhold til den prognosticerede høstdato.

force brought about by ethephon. This is probably due to the fact, that no abscission layer is formed across the vascular bundles in the fruit pedicel (*Wittenbach* and *Bukovac* 1972, *Bukovac* 1974). The problem of uneven ripening, when measured on fruit composition, is apparently not solved with an ethephon treatment.

High levels of soluble solids, acid, and anthocyanines and a low level of cyanide are essential requirements for industrial quality. This experiment shows clearly that early harvesting, which is possible with ethephon, should be avoided in order to meet these requirements. *Figure 6* shows the effect of advancing or delaying harvest date on fruit weight and yield of soluble solids in comparison to the values obtained at the predicted harvest time in the present experiment. Harvesting 10 days before this date reduces fruit weight and fruit yield with 18 per cent and the yield of soluble solids with 26 per cent. A 10 day delay of harvest, on the other hand, increases fruit yield with 8 per cent and yield of soluble solids with 17 per cent. – Delayed harvest also increases risks of fruit cracking and fungal attacks.

It is not surprising that the method for prediction of harvest date used here does not accurately predict optimum ripeness for industrial purposes, since this method was based on visual judgement of fruit ripening. However, it does give a useful guide as to when harvesting should start.

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