Project title:	Optimum picking dates for apples and pears
Project number:	TF 41 [Previously APRC SP 41]
Report:	Workshop report 1992
Project leader:	M Luton, ADAS
Key words:	apples, pears, picking dates, storage

This project report was originally issued by the Apple & Pear Research Council, under project number SP 41.

PAPERS PRESENTED AT THE

THIRD WORKSHOP ON OPTIMUM HARVEST DATE

HELD AT HRI, EAST MALLING

26th and 27th NOVEMBER 1992

Optimum picking date for Cox Orange apples grown in Bodensee region

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Assessment of maturity of apples has become very important during recent years due to the increasing volumne of apples being stored for long periods. Only apples picked at the optimum maturity stage are suitable for long-term storage because of better storage potential and organoleptical quality.
It is difficult to determine the optimum picking stage of apples because of the very complex but not obvious and independent change of ripening and maturity parameters. Additional, there exist considerable variations in ripening due to seasonal and local conditions. Therefore more accurate establishing of the optimum picking date (OPD) is necessary.
The proposed maturity index is calculated in a simple way from firmnes of fruit flesh, starch conversion and refractometric value as follows:
firmnes(F)/refractometer value(R) x starch conversion(S) (= F/RS-index).
Using this index I found specific values which seemed considerable independent of seasonal and local conditions for many varieties.

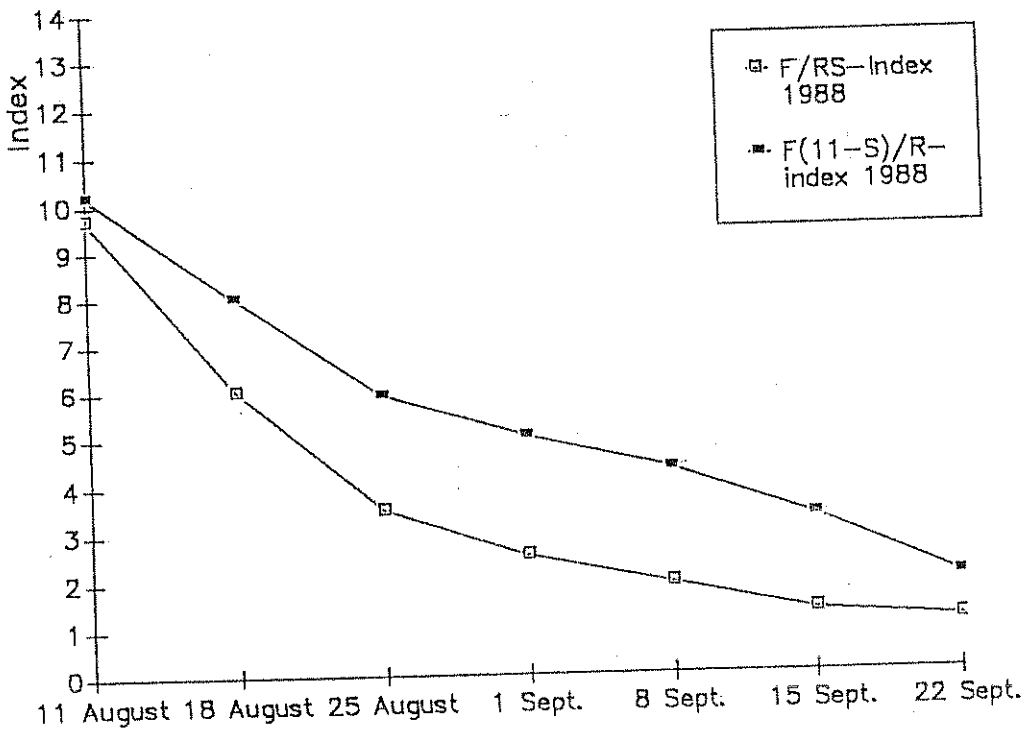
In my contribution I will present results from the variety 'Cox Orange' of the last seven years from 15 different orchards in the Bodensee region. In this region 'Cox Orange' is the first variety which opens the harvesting periode of apples for storage purposes and therefore 'Cox Orange' is very important for establishing the precice picking date, in general. The experiments were executed as deseribed in former proposals and instructions given by Anton de Jager and me.

Evaluation of storability:
Results of sensoric test, incidence of disorders and internal quality criteria (TSS, acid, firmness, colour) were individually judged by scores from 1 to 3 according their relative importance:

	values	scores	
a) sensory test (1-10)	7-10	3	
	4-6	2	
	1-3	1	max: 3
b) disorders (% healthy fruits)	96-100	3	
	90-95	2	
	<90	1	max. 3

For extrapolation it would be better to get more linear curves. Therefore I transformed F/RS values to F(11-S)/R values as proposed by Anton de Jager. The results for 5 different orchards and the mean of them for 1988 are shown.
The F(11-S)/R index curve is more linear especially in the first part, whereas in the second part both curves show a rather linear course.
The optimum F/RS values for 'Cox Orange' is located in that part of the curve where the changes become more slowly because of the decreasing starch conversion. Nevertheless you can find clear enough differences in F/RS-index between the different picking dates. This can be much smaller in such varieties which have nearly finished starch conversion at picking date, e.g. 'Jonagold', 'Golden Deliciou's. The opposite situation with a very pronounced change in index curve at harvest date exist for 'Gloster' and 'Elstar', which start with the starch conversion just at picking date. In general, the F/RS-methode gives clearer results for varieties which are in the beginning or in the middle of the starch conversion.

Fig. 2 Course of F/RS and F(11-S)/R index



Ripening and storability of Elstar, Jonagold, and Gloster apples from the Rheinland area in 1989 to 1991

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Fruits of the apple varieties Elstar, Jonagold, and Gloster from the Rheinland area store well in commercial CA- and our experimental stores, without problems due to excessive water loss or deseases. The fruit quality after such storage including one week shelf life may be defined as eating quality which is related to harvest date. CA-storage until April gave comparable results to cold storage until January, and the determined OD applies to both storage regimes. OD was often later than the beginning of the commercial harvest.

The figure gives the course of the quality parameters solube solids (B=brix%), firmness ($F=Ncm^{-2}$), starch index (S) and of the two calculated indexes (F/[S•B], F•[11-S]/B) according to Streif and De Jager, respectively. Solube solids peaked just before OD for Elstar and showed a minimum for Jonagold, but they rose continously for Gloster. Fruit firmness declined generally, but with different slopes. In case of Jonagold in 1990 is raised before OD. The starch index raised uniformly, except for Jonagold. The course of the calculated indexes declined continously for Elstar and Gloster, but differd greatly for the third variety.

Table 1 gives the minimum and maximum of brix, firmness, and starch values at OD and of the slopes before OD in the three seasons investigated. Slopes differ much more than min/max values. The variety Jonagold shows positive and negative slopes for the fruit firmness and hence derives for the indexes.

The relation of the error of determination to the slope of the parameter in each season gives the accuracy in days of OD determination in that season. The quotient of the maximum difference between two years of a parameter or index devided by the mean slope represents the fit of prediction of OD in different years.

Table 2 lists the range of the accuracy for one season and the fit of prediction, calculated from the data of the three years experiment. The brix data for one season show a wide range and are hence not sufficient to predict OD. The error exceeds OD by 40 days. Fruit firmness gives better accuracy in a single season as well as within the three years. Starch data correlate best of all parameters for the varieties Elstar and Gloster. The calculated indexes predict OD more precisely only for Gloster.

The variety Jonagold is outstanding. Because of raising or descending firmness just before OD the mean of years is undefined also for the calculated indexes. Starch data are of restricted use, as in most seasons this component has been converted completely to sugar before OD.

Tab.1: Parameter and indexes at OD and their slopes before OD (minimum and maximum in 1989 to 1991)

	Elstar min	Elstar max	Gloster min	Gloster max	Jonagold min	Jonagold max
brix (%) slope (/day)	13.6 -1.50	16.3 -0.01	11.3 0.01	14.5 0.09	12.4 -0.07	15.4 -0.04
firmn. (Ncm^{-2}) slope (/day)	59 -1.00	72 -0.25	80 -1.75	94 -0.67	65 -2.00	75 +1.00
starch index slope (/day)	6.1 0.10	6.7 0.15	4.1 0.23	5.7 0.40	7.2 0.0	10.0 +0.23
F/(S•B) slope (/day)	0.59 -0.22	0.80 -0.15	1.38 -0.61	1.62 -0.11	0.60 -0.04	0.60 +0.12
F•(11-S)/B slope (/day)	17.6 -0.83	22.4 -0.50	39.7 -3.91	45.4 -2.51	9.0 -1.35	16.6 +0.17

Tab.2: Accuracy of determination of OD in days within one season (error of determination/slope) and in 1989 to 1991 (max.difference/mean of slope)

	Elstar	Gloster	Jonagold
brix: season '89 to '91	0.7 - 10 43.8	1.1 - 9 72.8	1.5 - 2 56.8
firmn: season '89 to '91	2 - 8 23.6	1 - 3 10.6	1 - 3 -*
starch: seas. '89 to '91	3 - 5 5.1	1 - 2 5.2	2 - oo 33.6
F/(S•B): seas '89 to '91	4 - 5 12.1	0.3 - 1 0.8	0.5 - 12 -*
F•(11-S)/B: s '89 to '91	3 - 5 7.7	1 - 2 1.7	1.5 - 4 -*

* = undefined, slope may be pos. or neg.

From our trials in the Rheinland we may conclude that the starch-jodine-index is suitable in predicting OD, but the level varies with constituents such as sugar. The use of indexes, calculated from firmness, starch, and brix, results in slightly enhanced accuracy for the variety Gloster. Data of the last season (1992, not shown) demonstrate, that three years of experiments are not sufficient to give consistent results, which may be used generally.

The impact of different harvest date on post storage quality of five apple cultivars

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Introduction:

Maturity indexes F/R*S of five apple cultivars 'Elstar', 'Jonagold', 'Golden Delicious', 'Gloster' and 'Idared' from Ljubljana region were determined. Each variety was harvested four or five times in one week intervals. Firmness, starch content, soluble solids and titratable acids were measured. All the samples were stored for approximately six months at 0oC. After storage the same analyses were made once again as well as sensory evaluation. According to sensory evaluation the optimal harvest date was determined.

Methods:

Fruit firmness was measured by hand penetrometer on ten fruits four times on each fruit. Starch content was determined by dipping a transverse section of fruit in to iodine solution. Soluble solids were measured in the juice of each fruit by hand refractometer. Titratable acids were measured in fruit juice by titrating the juice with sodium hydroxide. Sensory evaluation test was performed by 10 people. Sweetness, acidity, firmness, juiciness and flavour were evaluated, each parameter by means of quality scale (1 - 5) where 5 means good and 1 bad. The optimal picking date was determined according to post storage sensory evaluation. Among four or five harvests the optimal one corresponds to the highest sum of sensory parameters.

golden

	* 1 #		* 2 #		* 3 #		* 4 #	
S.S.	12.60	15.30	12.60	14.20	13.40	14.65	13.40	13.95
A	0.71	/	0.63	/	0.62	0.30	0.57	0.33
F	8.97	6.30	8.30	6.39	8.50	6.20	7.94	5.97
S	1.35		2.90		4.30		7.45	
I	0.53		0.23		0.15		0.08	
sensory	14.6		15.7		18.7		19.2	

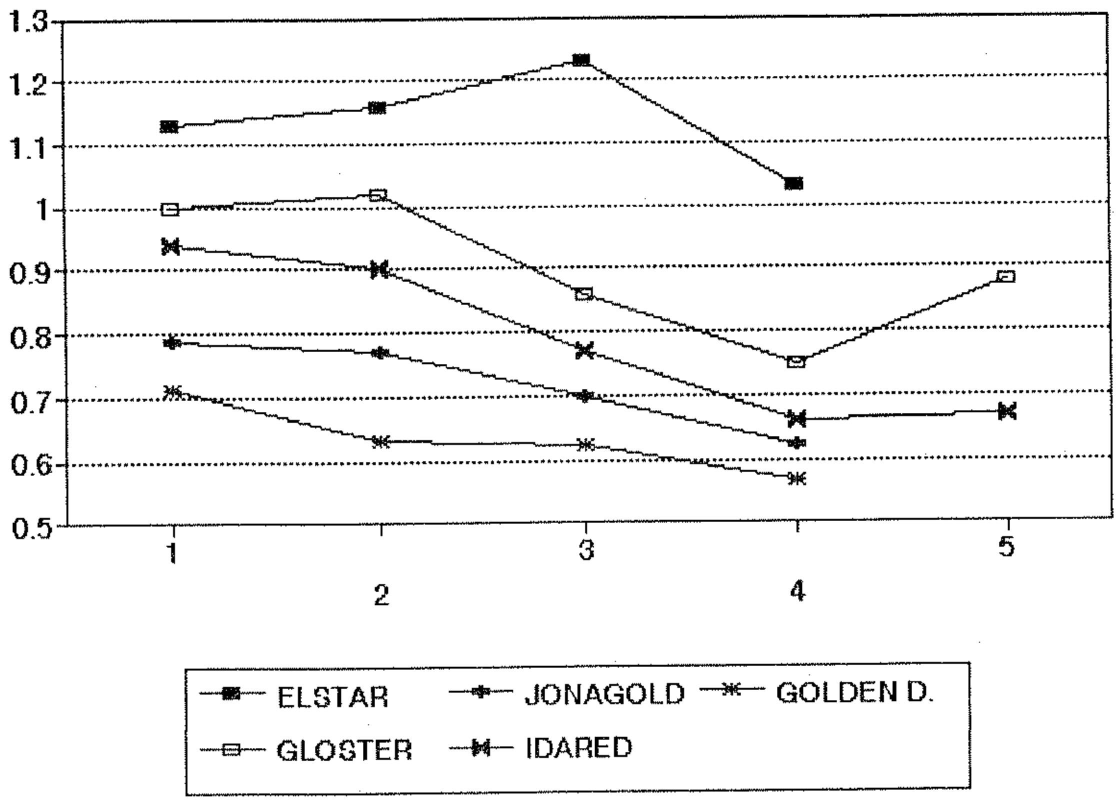
gloster

	* 1 #		* 2 #		* 3 #		* 4 #		* 5 #	
S.S.	11.8	14.4	11.9	14.3	11.9	14.2	11.9	14.7	13.4	14.6
A	1.00	0.60	1.02	0.83	0.86	0.74	0.75	0.66	0.88	0.62
F	10.1	5.93	9.96	5.72	9.60	5.91	9.30	5.65	9.40	5.32
S	1.95		2.6		3.1		2.9		4.0	
I	0.44		0.32		0.26		0.26		0.17	
sens.	12.5		13.75		14.25		16.00		16.25	

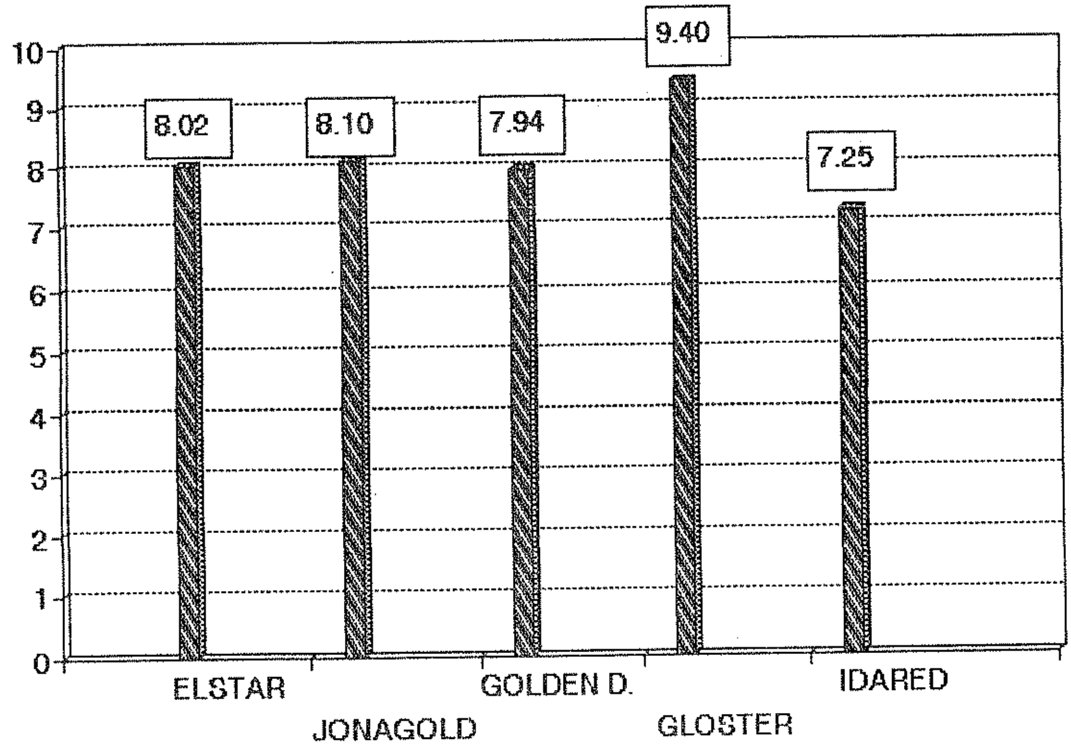
idared

	* 1 #		* 2 #		* 3 #		* 4 #		* 5 #	
S.S.	12.3	13.5	11.9	13.9	11.6	14.1	11.6	13.9	12.1	13.7
A	0.94	0.51	0.90	0.50	0.77	0.43	0.66	0.46	0.67	0.44
A	9.07	6.58	8.60	6.68	9.00	6.57	7.25	5.99	7.20	5.84
S	1.45		2.1		2.3		4.5		4.0	
I	0.51		0.34		0.32		0.14		0.15	
sens.	16.7		17.00		19.50		19.83		17.30	

ACIDITY g malic acid/100g juice

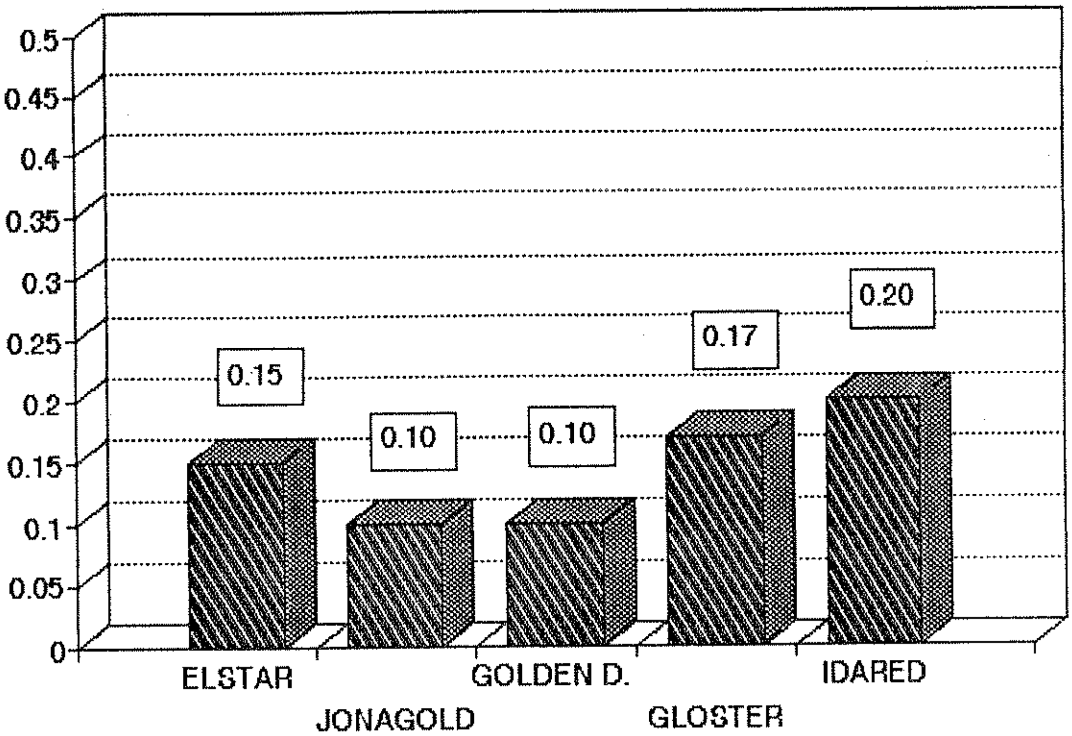


FIRMNESS (kg)



10
9
8
7
6
5
4
3
2
1
0
8.02
8.10
7.94
9.40
7.25
ELSTAR
JONAGOLD
GOLDEN D.
GLOSTER
IDARED

OPTIMAL F/RS INDEXES



Optimum harvest date of Conférence and Jonagold in the period 1989 - 1992 in Belgium

1. Methods:

- varieties: apple: Jonagold
  pear : Conférence

- sampling: starting a few weeks before the estimated optimum harvest date for long storage, we picked the samples at weekly intervals, continuing until a few weeks after the optimum harvest date. The samples are picked from 10 trees (1 fruit/tree) at random; each fruit is labeled and the tests are performed on individual fruits.

- measuring procedures:
  - fruit firmness: we removed the peel at two opposite sides on the equator of the fruits and measured the firmness with a Effegi-penetrometer with a convex probe of Ø 11 mm. The results are expressed as $kg.cm^{-2}$
  - starch-iodine test: the apples and pears are cut through the equatorial line and the surface is dipped in a lugolsolution (3g I_2 and 10 g KI/l destilled water). After 1 minute the blue-black stained area is compared with the standard photographs in scores from 1 (= totally black) to 10 (= totally white)
  - refractometer value: the refractometervalue of the juice of each fruit is measured with a refractometer and the results are expressed in brix.

2. Results:

Summary of the results 1991 (mean and standard deviation)

Conférence

Date	Firmness (kg.cm^{-2})	refraction (brix)	Starch value	Streif-index
23/8	12 ± 0	9,99 ± 0,6	2,1 ± 0,3	0,57
30/8	12 ± 0	10,76 ± 0,8	1,7 ± 0,8	0,66
06/9	12 ± 0	12,07 ± 0,2	2,0 ± 0,7	0,50
13/9	12 ± 0	11,0 ± 0,5	1,9 ± 1,1	0,57
20/9	11,8 ± 0,3	11,44 ± 0,8	2,8 ± 0,6	0,37
27/9	11,0 ± 0,4	12,95 ± 0,5	4,9 ± 2,0	0,17
04/10	10,9 ± 0,6	13,52 ± 0,7	8,5 ± 0,7	0,09

Jonagold

Date	Firmness (kg.cm^{-2})	refraction (brix)	Starch value	Streif-index
06/9	11,0 ± 0,7	12,58 ± 0,8	1,0 ± 0	0,87
13/9	9,6 ± 0,9	11,77 ± 1,1	1,0 ± 0	0,81
20/9	9,4 ± 0,5	13,30 ± 0,9	1,4 ± 0,5	0,50
27/9	8,7 ± 1,1	13,21 ± 0,3	2,5 ± 1,1	0,26
04/10	9,1 ± 1,2	13,96 ± 0,8	3,9 ± 1,7	0,17
11/10	8,7 ± 0,7	15,25 ± 0,9	5,7 ± 1,5	0,10
18/10	8,1 ± 1,1	15,05 ± 1,3	7,6 ± 1,3	0,07

Summary of the results 1992 (mean and standard deviation)

Conférence

Date	Firmness (kg.cm^{-2})	Refraction (brix)	Starch value	Streif-index
21/8	12 ± 0,1	12,20 ± 0,7	1,8 ± 0,2	0,55
28/8	12 ± 0	13,12 ± 0,5	2,7 ± 1,3	0,34
01/9	11,8 ± 0,3	14,34 ± 0,8	3,7 ± 2,2	0,22
08/9	12 ± 0,4	13,72 ± 1,3	4,7 ± 2,6	0,19
15/9	11,5 ± 0,8	14,20 ± 0,6	6,5 ± 2,0	0,12
22/9	10,1 ± 3,7	13,85 ± 1,2	8,1 ± 0,9	0,09

Jonagold

Date	Firmness (kg.cm^{-2})	Refraction (brix)	Starch value	Streif-index
01/9	8,6 ± 0,8	11,35 ± 0,7	1,6 ± 0,5	0,47
08/9	9,1 ± 1,2	10,68 ± 0,9	2,6 ± 1,0	0,33
15/9	8,0 ± 0,6	12,12 ± 1,1	5,9 ± 1,6	0,13
22/9	8,0 ± 0,8	12,09 ± 0,4	6,8 ± 0,6	0,10
28/9	7,9 ± 1,2	12,22 ± 1,1	7,7 ± 0,8	0,08
05/10	7,5 ± 0,9	11,77 ± 0,8	7,8 ± 1,1	0,08
12/10	7,3 ± 0,8	11,93 ± 1,0	9,3 ± 0,7	0,07
19/10	7,4 ± 0,9	11,77 ± 1,4	9,6 ± 0,5	0,07

- Can we determine <u>one single Streif-value</u> who is usable during different years?
- Can we predict <u>in advance</u> at which moment we will reach this value?
- Is the use of <u>only the starch-index</u> also valuable to determine the optimum harvest date?

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Prediction of Optimum Harvest Date of Jonagold by the Harvest Index according to Streif

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Abstract
During 3 years fruit quality parameters of Jonagold apples have been collected for 32 orchards on the basis of two samples per week starting 4-6 weeks before estimated optimum harvest date (OHD) until the end of the harvesting period. Over a period of 3 weeks, including OHD, fruits were harvested four times for storage. Based on the fruit quality after storage, either tasted or measured, OHD was calculated. These data were used to determine the so-called 'Streif-index' at OHD from the curves of index versus time of the individual orchards. These curves fit generally very well (R^2>95%) to the general formula ln(index)=a+(b*d) in which a and b are constants characteristic for the orchard and d=daynumber. Data were normalized by setting time at OHD at 0 allowing for a grouping of all curves to a common formula of the same form with a=-2.32 and b=-0.051 (R^2=87%). Reversing this relationship yields a predicting relation of the form d=-40.2-16.9*ln(index) in which d= the number of days from OHD (R^2=87%). Using this relation the standard error in units of the Streifindex was translated into the error in days. The 95% confidence interval of the mean was ≤ +/- 1.5 day. The accuracy of the prediction at one point in time for the individual orchard is much less. A method has to be found to increase this accuracy.

Introduction
The demand for an objective method for estimating optimum harvest date (OHD) for pome fruit is widespread. Existing systems range from depending solely on the starch breakdown (apples) or firmness (pears) to extensive monitoring a large number of fruit parameters (Washington State Apple maturity Program). Attempting to develop a system for calculation of OHD, Streif (1983 and 1989) proposed a laboratorysystem including 8 parameters followed by a practical system including 3 parameters. The latter system might be applied by growers themselves. The system is based on the combination of firmness, refractometric index and starch breakdown into an index. For practical application this index should fullfill two requirements: the preharvest development of the index in time should be characteristic and ODH should coincide with a more or less constant value of the index. In the present work these two aspects are tested for the apple variety Jonagold.

Methods
sampling
Samples of 25 fruits were taken two times a week starting 4-6 weeks before expected OHD. Orchards were distributed between different soil types, + or - fertigation and except for 1991 also different regions. Fruits were picked from 5 trees, 5 fruits per tree, from the outer part of the western side between knee and shoulder. Early maturing fruit (mostly in the top) and very small or large fruits were rejected. After the first fruit has been chosen the other four fruits should be its

the basis of 32 orchards over the 3 years:

(1) $\ln(\text{index}) = a + b*d$ $R^2=93\%$

where a and b are constants characteristic for each orchard and d is Julian daynumber.

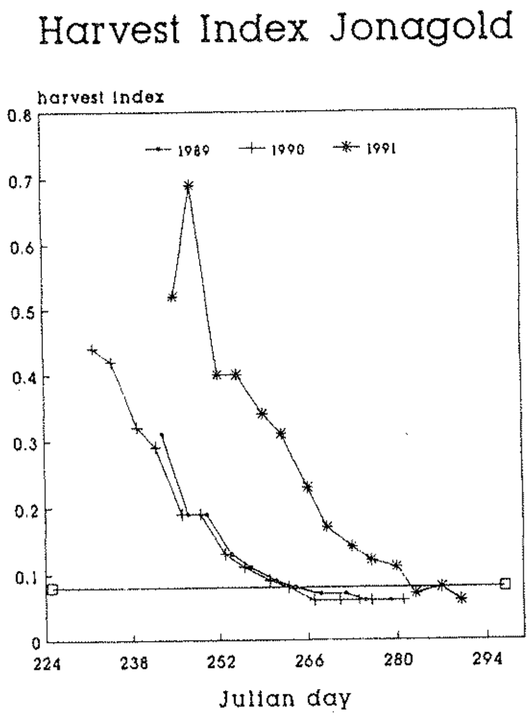
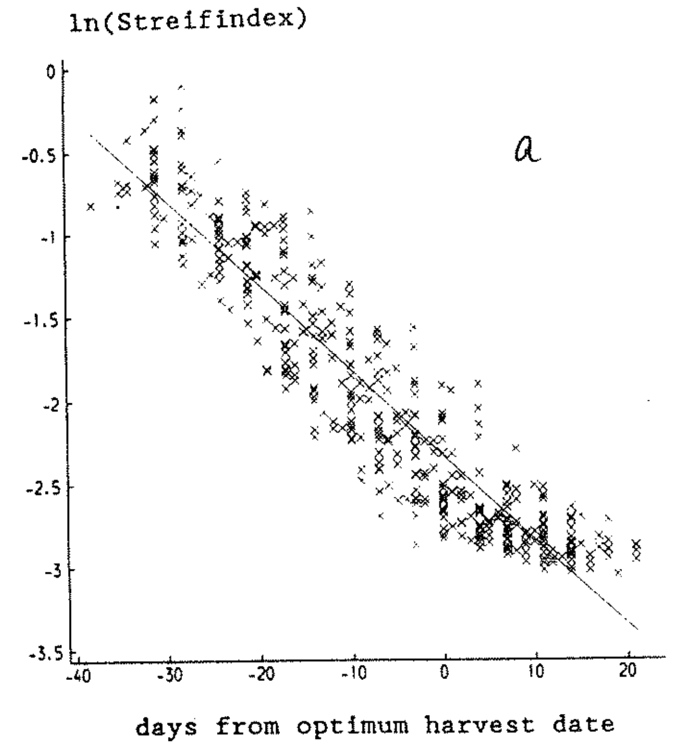


Figure 1.
Streifindex of Jonagold as a function of time for the years 1989, 1990 and 1991.

Table 1.
Number of days ahead or behind foregoing years comparing identical values of the harvest index.

years	90-89	91-90	91-89
Julian day			
245	2	-	-
252	2	19	-
259	1	20	17
266	3	20	18
273	-	21	20
280	-	22	21
287	-	24	21



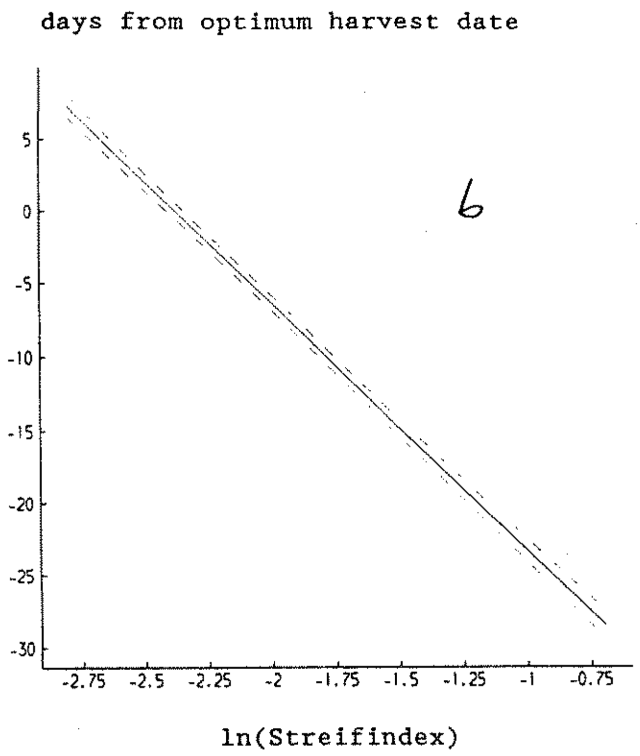


Figure 2a.
Relationship between normalized time and ln(streifindex) for all 32 orchards in the years 1998, 1990 and 1991 with t=0 at OHD and OHD determined by function (1) according to calculated quality after long storage and 2 weeks of shelf life (function (2)).

Figure 2b.
Reversal of the relationship in figure 2a with the 95% confidence interval for the mean (prediction for a group of 32 orchards) (function (3)).

accuracy of the method
The most important question is how accurate the method can be either comparing groups of orchards (years, regions) or comparing individual orchards. Table 3 shows the 'translation' of standard errors of the

Table 3.
Mean OHD with 95% confidence values as days before (-) and after (+) OHD for 32 orchards over 3 years (89-91) and for each of the years apart.

year(s)	89-91	89	90	91
mean	-1.1	0.3	0.1	4.5
S(mean)+	1.3	1.3	1.5	1.7
S(mean)-	1.2	1.3	1.4	1.6

Estimation of picking date for 'Jonagold'

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Introduction
At the Department of Food Science and Technology we have made experiments with estimation of picking date for the apple variety 'Jonagold' according to the methods proposed by J. Streif Versuchsstation, Bavendorf. This paper is a presentation of results from two years.

Materials and Methods
Sampling for testing fruit ripeness took place in the period August 14, until October 9, in 1990 and August 20, until November 12, in 1991. At each of the last four sampling dates apples were picked for storage.
Storage conditions were +1°C, 3 % CO_2 and 2 % O_2. The apples were evaluated after storage for five months (February 19 in 1991 and March 10 in 1992) and seven months (April 23 in 1991 and May 12 in 1992). The evaluation was carried out after storage and additionally 14 days at 12°C.

Fruit firmness, soluble solids and starch content were determined immediately after picking. The harvest index defined as firmness/(% total soluble solids * starch content) was calculated.
After storage the moisture were loss, disorders and diseases determined. After additional one day at 20°C firmness, colour, soluble solids and acidity were measured. Sweetness, sourness, flavour, crispness, juiciness and taste were evaluated by eight trained panellists.

Colour, expressed as Hunter Lab values, was measured with a Hunter Colorimeter. Firmness was measured by use of an Instron apparatus (diameter 11 mm, velocity 50 mm/min, depth 8 mm, peeled fruit) on the equator of the fruit on to opposite sides.
Measurements of starch breakdown vas made by using the potassium iodide test with scores from 1 (black) to 10 (white).
Samples for further analysis were prepared by homogenizing with water in a Waring blender.
Titratable acid was determined by use of a Mettler DL 4 automatic titrator. 10g of blended material was titrated to pH 8.1 with 0.1 N NaOH and the titratable acid was calculated as malic acid.
Soluble solids was measured, in filtrates of the blended material, by use of a Baush & Lomb refractometer.

Effect of picking date on storage life and quality

The wastage, due to moisture loss, disorders and diseases, is higher at the late pickings and after extended storage (Table 1). Only a small difference was seen in moisture loss (2.3 - 3.5 pct.). The most dominant disorder was soft scald responsible for up to 30 - 40 pct. wastage. As diseases was seen Gloeosporium rot and rot in wounds.

The fruits picked late were more firm (not in 1991) contained less malic acid and appear more red. There was no difference in sugar contents the two years.

The results from sensory evaluation in 1990 showed that the fruits picked late were more sweet, less sour, had more flavour and a better taste than the fruits picked earlier. There was no difference in taste between the picking dates in 1991.

Table 2. Soluble solids, malic acid, firmness and colour after storage. The values is average of the two storage periods. The more negative CIE a-values the more green. Picking date = days from August 13th.

Picking date		Soluble solids pct.		Malic acid mg/g		Firmness kg/cm²		CIE a value	
1990	1991	90	91	90	91	90	91	90	91
36	56	14.3	11.9	5.8	4.8	5.4	4.4	-5.3	-3.6
43	63	14.4	11.7	6.1	4.8	5.4	4.5	-2.5	-2.6
50	70	14.3	11.9	5.7	4.4	5.7	4.3	3.4	0.3
57	84	14.2	11.8	5.6	4.2	5.7	4.3	5.3	2.6
LSD		ns	ns	ns	0.4	0.3	0.2	4.4	4.9

Conclusion

The optimum picking date for 'Jonagold' is first of all determined by the incident of disorders and secondly by the quality attributes firmness and acidity.
The picking date with least wastage and the best quality attributes have been obtained at an harvest index between 0.13 - 0.18 for the two years and storage periods.

EUROPEAN OPTIMUM PICKING DATE STUDY 1991/92

HORTICULTURE RESEARCH INTERNATIONAL, EAST MALLING IN COLLABORATION WITH THE AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE.

David Johnson and Keith Pearson, HRI, East Malling
Martin Luton and Adrian Wallbridge, ADAS, Maidstone

MATERIALS AND METHODS

Samples of Conference pears for maturity and storage tests were taken from the same two sites (Messrs Redsell and Scripps) used in the two previous years. Samples for maturity assessment were taken on nine occasions from both sites (22nd and 29th August and 2nd, 5th, 9th, 12th, 16th, 19th, and 30th September). Three further samples were taken at Redsell's only (3rd, 7th and 10th October). Samples for storage were taken from both sites on 12th, 19th and 26th September and additionally at Redsell's on 3rd and 10th October. In 1989 and 1990 sampling for storage had commenced on 31st and 30th August respectively and finished on 22nd and 20th September respectively. The lack of any differences in the storage qualities of CA-stored pears from the final pick in previous years prompted a later start and finish to sampling for storage in 1991. At each sampling date measurements were made of soluble solids concentration (refractometer) and firmness (motorised penetrometer fitted with an 8mm probe) of the fruit and a starch-iodine staining test was carried out on equatorial slices of the fruit (score 1 = totally black, score 10 = totally white). In previous years concentric rings were used to assess % area stained black (see *report for East Malling Research Station for 1978, 215-6*) and then converted to a score ranging from 1 to 10 according to photographs supplied by Dr de Jager (see attached).

Samples of pears for storage were precooled and placed into a commercial controlled atmosphere (CA) store (East Kent Packers Ltd) maintained at a nominal 2% oxygen with less than 1% carbon dioxide at a temperature of -1°C. Fruit samples were removed from store on 14th February and 30th April 1992 and delivered to East Malling and placed into a room at 18°C. Fruit firmness measurements were made on 10-fruit samples over 5 consecutive days. Taste panel asssessments (profile tests) were then carried out on fruit from each harvest date/site by 18 (tasted 19th February) or 20 (tasted 6th May) trained panellists. Sensory data was subjected to an analysis of variance using panellists as 'replicates' but no other statistical analysis was possible on any other data since there was no replication of samples for each pick date.

Table 1. Effect of harvest date on the eating quality of Conference pears from two orchards (Messrs Scripps and Redsell) stored in CA (2% O_2, <1% CO_2) at -1°C until 14th February (Redsell) and 30th April (Scripps) then ripened for 5 or 6 days at 18°C. Profile tests were carried out by trained panellists and each attribute was scored on a scale 0-100 and acceptability was rated 1 (very bad) to 9 (excellent).

Sensory attribute		*Pick* 1	2	3	SED
Flavour	Scripps	47	60	63	5.1
	Redsell	42	49	58	7.3
Firmness	Scripps	50	47	41	4.0
	Redsell	40	48	38	3.5
Juiciness	Scripps	58	68	71	4.0
	Redsell	65	60	76	3.7
Sliminess	Scripps	32	35	32	3.1
	Redsell	24	25	25	2.8
Grittiness	Scripps	46	35	43	3.3
	Redsell	38	40	33	5.6
Sweetness	Scripps	46	58	62	5.4
	Redsell	47	48	58	5.2
Astringency	Scripps	27	23	25	3.4
	Redsell	12	12	15	2.0
Acceptability	Scripps	5.2	6.3	6.4	0.37
	Redsell	5.6	5.8	6.5	0.36

Table 2. Harvest Maturity parameters related to the storage and eating quality of Conference pears

	Start of harvest		*Finish harvest*
	Scripps 19.9.91	*Redsell 26.9.91*	*Redsell 3.10.91*
R-% soluble solids (refractometer)	13.0	13.0	13.2
S-starch score (black = 1, white = 10)	6.2	6.4	7.9
% starch cover (approx)	30.0	30.0	10.0
starch cover % maximum	40.0	37.5	12.5
F-firmness (N)	56.2	55.0	48.0
F/R*S	0.7	0.7	0.5
F*(11-S)/R	20.7	19.5	11.1

CONCLUSIONS

It has long been recognised that best eating quality in Conference pears is associated with low starch contents and high soluble solids when harvested. The starch iodine test has been used for many years to indicate the commencement of harvest ie when average starch pattern has decreased to two-thirds of the maximum coverage. Pears stored in the formerly recommended CA conditions of 5% CO_2 and 5% O_2 were susceptible to CA-induced injury and the safe period was normally 5-6 days from the optimum start date. It was recognised however that picking for air storage could be extended considerably later than for CA.

Using the starch iodine test as currently recommended *(see Report for East Malling Research Station for 1970 p 149-51 and 1978 p 215-16)* the start dates for harvesting at both sites would have been about 16th September. Whilst this would have predicted a slightly early (approx 3 days) commencement of harvest than that required for optimum quality at Scripps the starch test alone would have predicted a date about 10 days early at Redsells. However the harvest index values associated with the beginning of the optimum harvest period were similar for both sites and therefore might be a more reliable guide to harvest dates for Conference than the use of single parameters. Since pears continue to size up to the time they are picked premature picking should be avoided. Additionally delayed harvest in order to maximise quality should be

International Pear Trial (Redsell).

Removed from CA store February 1992.

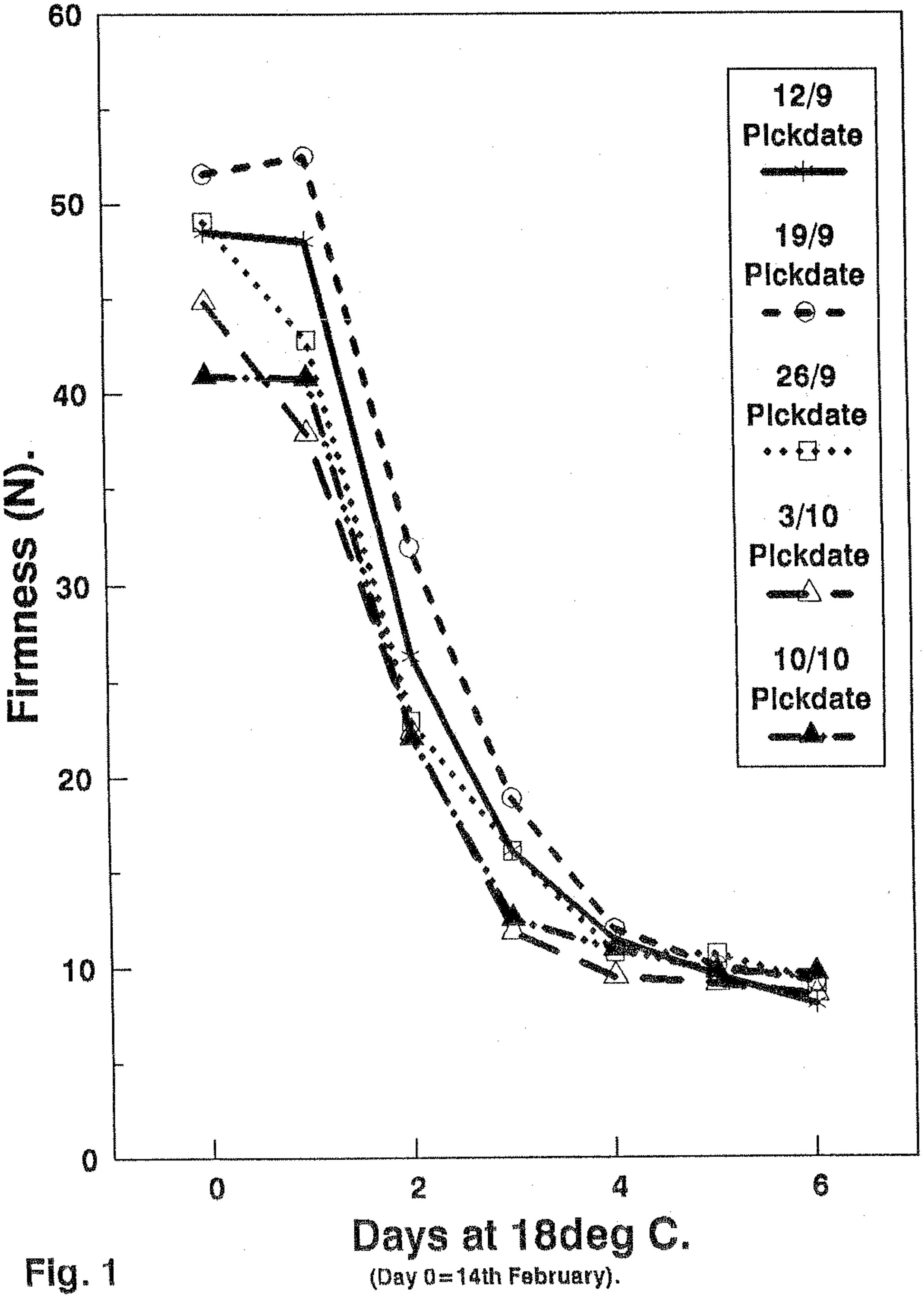

Fig. 1

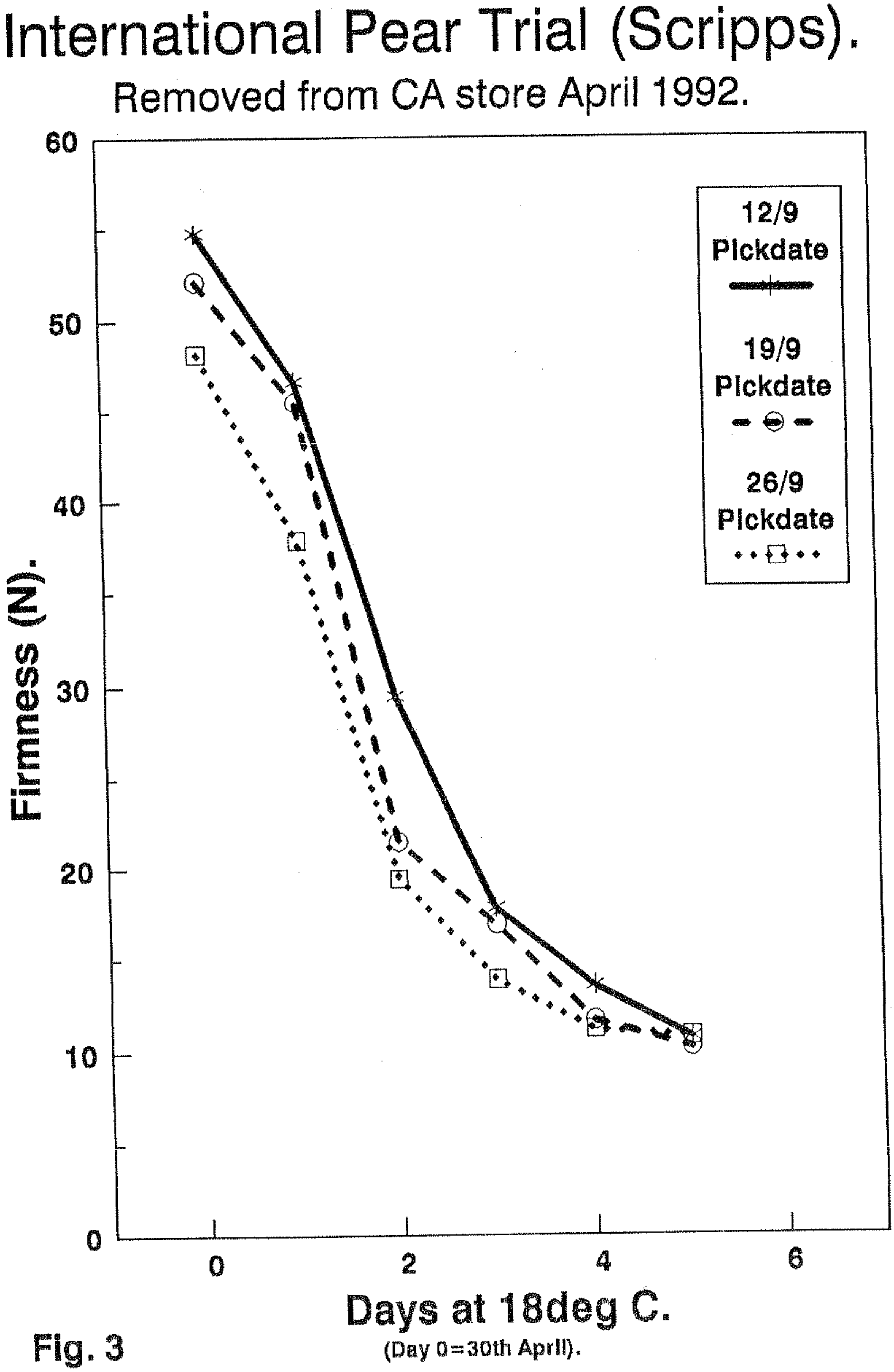
International Pear Trial (Scripps).
Removed from CA store April 1992.
60
50
40
30
20
10
0
Firmness (N).
0
2
4
6
Days at 18deg C.
(Day 0=30th April).
12/9 Pickdate
19/9 Pickdate
26/9 Pickdate

Fig. 3

1991 Conference Picking Date Study.

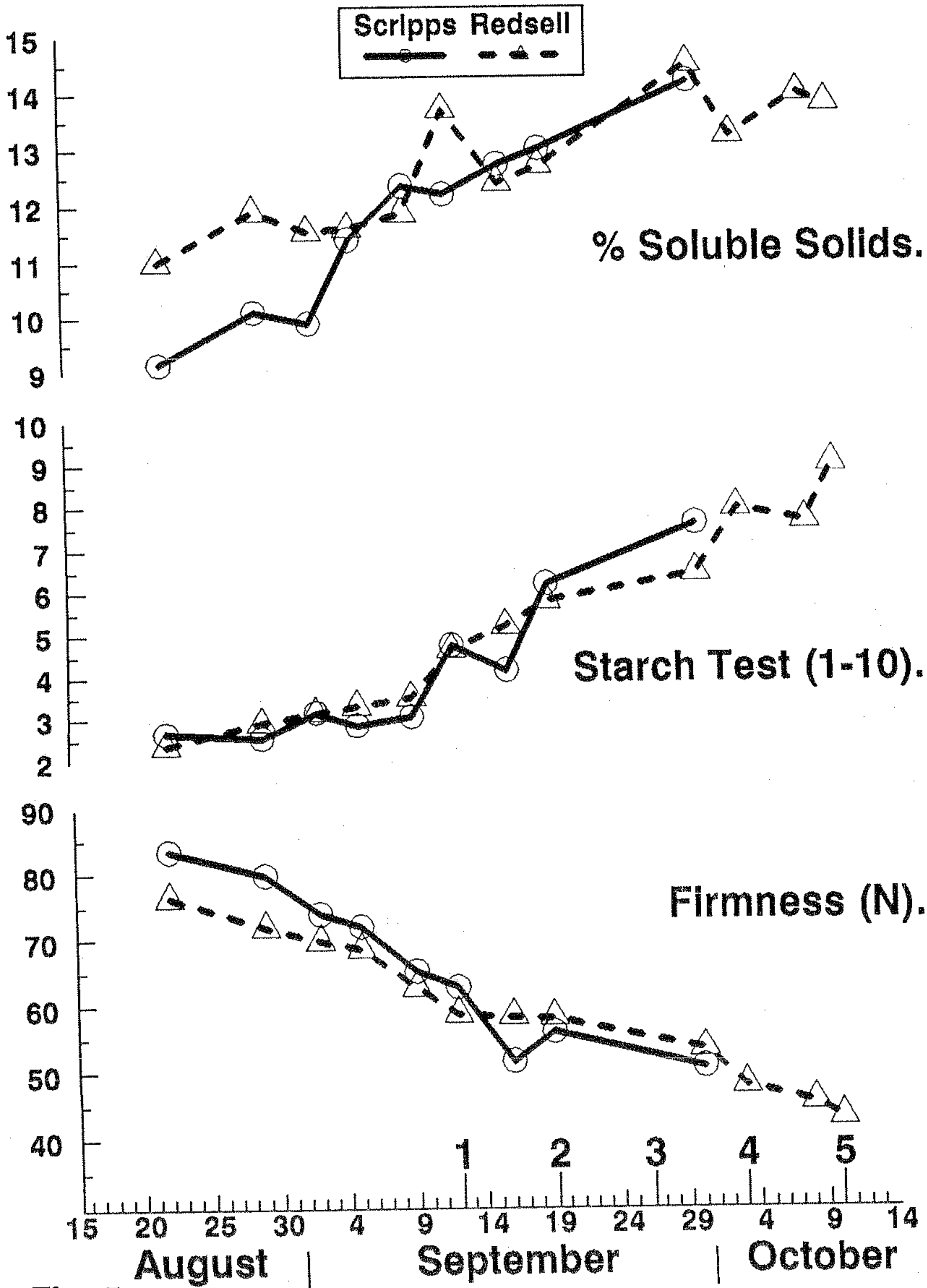

Fig. 5

Workshop on Optimum Harvest Date
25-26 November 1992
East Malling

HARVEST INDEXES FOR COMICE PEARS IN RELATION TO EATING QUALITY

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Introduction

Right timing of harvest is the key for storage and eating quality of pears, as of other fruit. Italian consumers like especially sweetness, juiciness and softness in pears, and complain about being sometimes hard or grainy. A research project is being carried out to verify the possibility of using skin colour as a criterium for harvesting pears.

Materials and methods

In 1990 Comice pears were harvested at weekly intervals and classified by colour at each harvest. A painted table was prepared for each colour class taking pears as models. Seven tables were prepared, but some of them were not sufficiently different to be easily discriminated, so only three tables were selected, with colour differing by a small hue. In 1991 in one orchard near Faenza (Emilia-Romagna region) Comice pears were harvested according to the three color tables: when the majority of fruits in the orchard reached the colour of one table, about 300 fruits of that colour were harvested from 15-20 trees. Harvests for the three colours were respectively on 24 Aug, 2 Sep and 14 Sep. At harvest mass, skin colour, starch content, soluble solids (s.s.) and firmness were measured on a sample of 30 fruits. Pears were stored in C.A. (3% O_2, 3% CO_2) at -0.5 / 0 °C. Sixty fruits were taken from storage room at four dates during storage (on 8 Jan, 7 Feb and 1 Mar directly from CA, on 16 March after 15 more days in cold storage), then were transported to IVTPA, Milano. At arrival colour of skin, mass, firmness, soluble solids and acidity was measured on a sample of 20 fruits; the rest was left at 20°C until eating ripe. Only at the first date, the fruits of the 2nd and 3rd harvest were kept in cold storage respectively for two and four more days before ripening. When pears were eating ripe, were assessed by a taste panel (11-13 people) for the intensity of sweetness, juiciness, firmness, acidity, aroma, astringency and graininess on unstructured scales with anchors near the extremes. Taste panel was composed by Institute staff with a wide experience of tasting, and by some students without experience. Each judge received a slice of fruit cut into pieces in a plastic beaker for each harvest; the three harvests were presented in random order and were identified by three digit random numbers. The tasters assessed the pears in individual booths, and had water to rinse their mouth between samples. At time of tasting, firmness, s.s. and per cent juice was measured on the same tasted fruits. To measure %

Table 1

COMICE PEARS

MEANS OF VARIABLES MEASURED

AT HARVEST

	STARCH	MASS	SS	FIRMNESS	L	A	B	HUE	SATUR
HARVEST									
1	3.90 a	250.90 b	14.18 b	58.79 a	59.70 b	-14.36 b	39.09 b	1.92 a	41.71 b
2	3.35 b	299.00 b	14.98 a	53.19 b	59.32 b	-13.68 b	41.46 a	1.89 a	43.74 a
3	2.45 c	392.25 a	15.33 a	50.08 b	62.30 a	-8.73 a	40.49ab	1.78 b	41.56 b

AFTER STORAGE / AFTER RIPENING

DATE	HARVEST	ACIDITY	MASS	SS	FIRMNESS	L	A	B	HUE	SATUR	% JUICE
1	1	6.38	227.45	16.97	50.08	59.96	-10.90	37.91	1.85	39.50	22.41
	2	6.46	285.15	17.39	47.73	59.69	-11.31	37.99	1.86	39.68	25.06
	3	5.81	368.55	17.10	42.23	61.03	-10.24	39.40	1.82	40.78	24.84
	mean	6.22	293.72	17.15	46.68	60.22	-10.82	38.43	1.85	39.99	24.10
2	1	5.57	244.20	17.14	55.25	57.47	-9.16	36.57	1.81	37.81	26.68
	2	5.70	288.30	17.08	51.55	61.35	-12.32	39.34	1.87	41.27	41.40
	3	5.48	388.45	16.73	48.98	59.67	-7.80	38.39	1.77	39.32	42.18
	mean	5.58	306.98	16.98	51.93	59.50	-9.76	38.10	1.82	39.47	36.75
3	1	5.59	237.70	16.56	49.64	56.84	-10.21	40.48	1.81	41.88	27.76
	2	4.93	263.00	17.08	44.22	61.18	-9.38	42.14	1.79	43.24	39.61
	3	5.26	354.40	16.67	44.14	58.66	-9.48	42.12	1.79	43.27	42.16
	mean	5.26	285.03	16.77	46.00	58.89	-9.69	41.58	1.80	42.80	36.51
4	1	5.02	254.16	17.30	49.30	58.77	-8.78	38.58	1.79	39.77	30.76
	2	4.57	279.77	17.82	44.10	60.69	-8.92	38.47	1.79	39.63	37.84
	3	4.97	338.85	17.60	41.37	60.62	-6.84	38.75	1.74	39.44	41.74
	mean	4.85	290.93	17.57	44.92	60.03	-8.18	38.60	1.78	39.62	36.78
mean	1	5.64	240.88	16.99	51.07	58.26	-9.76	38.38	1.82	39.74	26.90
	2	5.42	279.06	17.34	46.90	60.73	-10.48	39.48	1.83	40.96	35.98
	3	5.38	362.56	17.03	44.18	59.99	-8.59	39.67	1.78	40.70	37.73
	mean	5.48	294.16	17.12	47.38	59.66	-9.61	39.18	1.81	40.47	33.54

COMICE PEARS AT HARVEST

Table 2

Correlation Matrix (60 Observations)

	STARCH	MASS	SS	FIRMNESS	L	A	B	HUE	SATUR
STARCH	1.00								
MASS	-.54**	1.00							
SS	-.35**	0.55**	1.00						
FIRMNESS	0.50**	-.24	-.21	1.00					
L	-.37**	0.24	0.14	-.36**	1.00				
A	-.46**	0.39**	0.30*	-.31*	0.06	1.00			
B	-.22	0.12	0.14	-.40**	0.28*	-.26*	1.00		
HUE	0.51**	-.43**	-.33**	0.38**	-.10	-.98**	0.10	1.00	
SATUR	0.01	-.06	-.02	-.20	0.20	-.62**	0.92**	0.48**	1.00

Table 3

Principal Component Analysis

	Eigenvalue	Proportion	Cumulative
PRIN1	3.40200	0.378000	0.37800
PRIN2	2.52679	0.280755	0.65875
PRIN3	1.00024	0.111138	0.76989
PRIN4	0.78610	0.087345	0.85724
PRIN5	0.50622	0.056246	0.91348
PRIN6	0.43720	0.048578	0.96206
PRIN7	0.33661	0.037401	0.99946
PRIN8	0.00422	0.000469	0.99993
PRIN9	0.00062	0.000069	1.00000

Eigenvectors

	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5
STARCH	0.4075	-.1883	0.0717	-.1180	0.5738
MASS	-.3762	0.1153	0.4907	0.1641	-.4070
SS	-.3070	0.1165	0.6539	-.0408	0.5805
FIRMNESS	0.2963	-.3027	0.4287	0.2244	-.2706
L	-.1770	0.3045	-.2704	0.8109	0.2828
A	-.4641	-.2515	-.1811	-.1899	0.0748
B	-.0031	0.5795	-.0163	-.3316	-.0271
HUE	0.4779	0.1611	0.1846	0.2549	-.0675
SATUR	0.1878	0.5727	0.0472	-.1956	-.0616

Table 5

Correlation of 1st principal component scores with original variables

HARVEST	-.83
STARCH	0.75
MASS	-.69
SS	-.57
FIRMNESS	0.55
L	-.33
A	-.86
B	-.01
HUE	0.88
SATUR	0.35
PRIN1	1.00

Table 4

Means of scores for 1st principal component

HARVEST		
1	2	3
1.61 a	0.49 b	-2.10 c

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Optimum Harvest Dates for MacSpur, Spartan, Jonathan and Golden Delicious

Material and Methods.

The studies were carried out in the years 1986-1991. Apples were harvested from University experimental orchards next to Kraków / South Poland /. Apples of each studied cultivar were picked always from the same 30 trees.

Each year samples were picked first approximately 5-6 weeks before expected optimum date and than at 7-10 days interwals to the end of harvest period. For all samples the levels of different maturit and quality parameters were measured, among them flesh firmness, soluble solids, acids /according to standard procedures/, starch index / 9 point scale / and Induced Ethylene Production /IEP/ according to Dilley /1981/.

Based on the changes of maturity and quality parameters provisiona optimum harvest dates /OHD/ were determined. With the respect to provisional OHD fruits were picked 3-4 times in one week interwals too early, at optimal harvest time and too late.

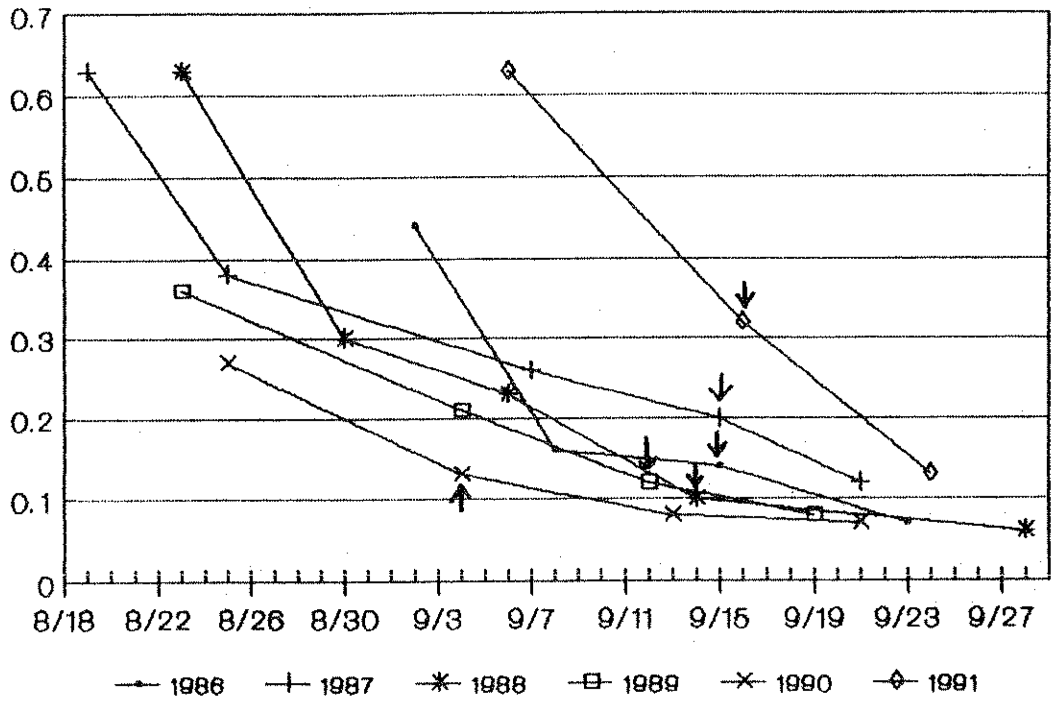
Immediately after picking, apples were brought into storage and stored at recommended in Poland conditions for long term storage. After storage period plus shelf life the optimum harvest dates /OHD/ were estimated according to method by Streif. Measured parameters were flesh firmness, soluble solids, acids, taste, % rot and % physiological disorders.

For each sampling date harvest index / HI / values were calculated HI-1 similar to Streif and respectively HI-2 to de Jager.

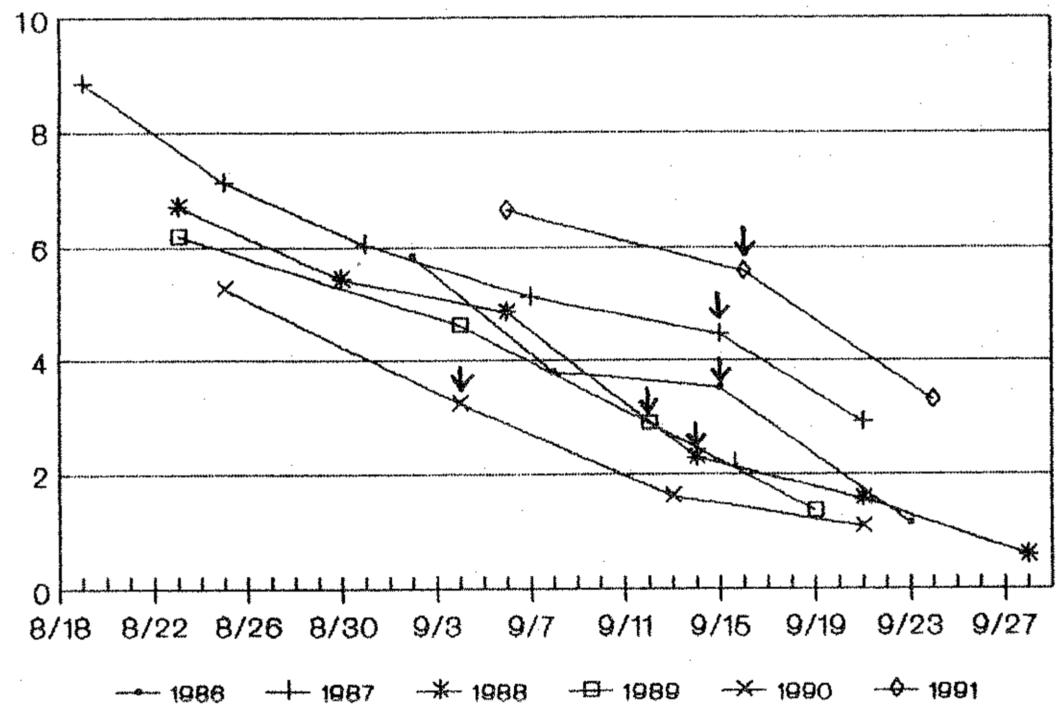
Results

All data are presented in following graphs. Estimated Optimum harvest dates /OHD/ are marked for each of studied years by an arrow. For cv. MacSpur OHD were when HI-1 values for apples were within the range from .20 to .10, with the exceptional value .32 in 1991. Corresponding to OHD values of HI-2 were respectively from 4.47 to 2.29 and in 1991 5.58. Both HI-1 and HI-2 in 1991 were high due to high flesh firmness at picking time.

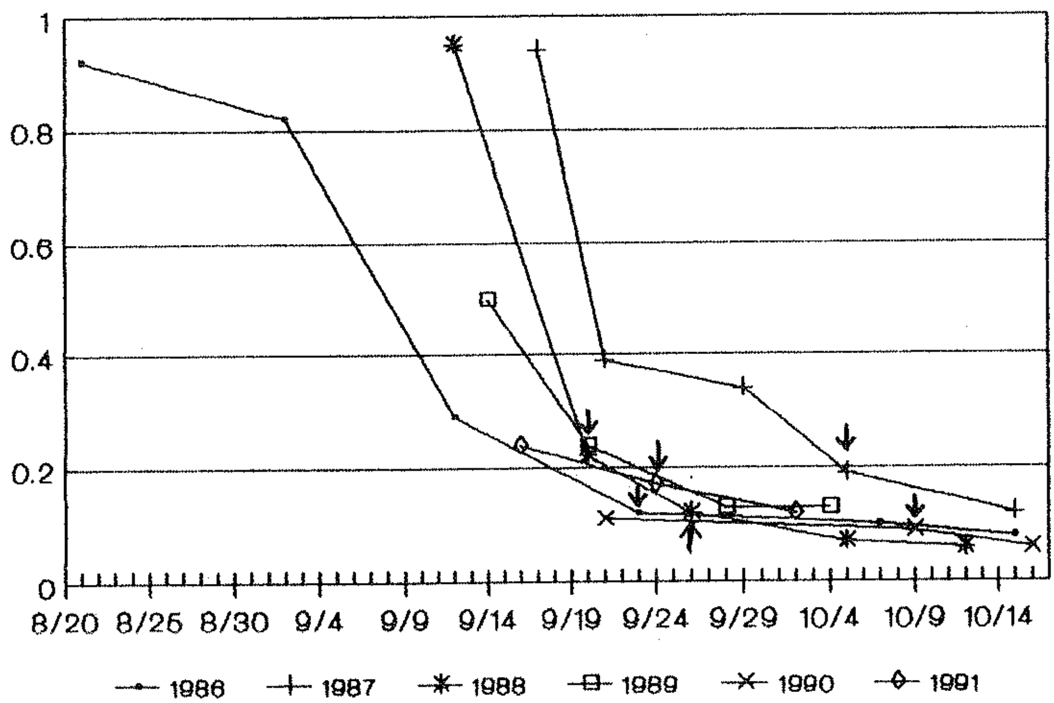
Harvest Index I cv.MacSpur



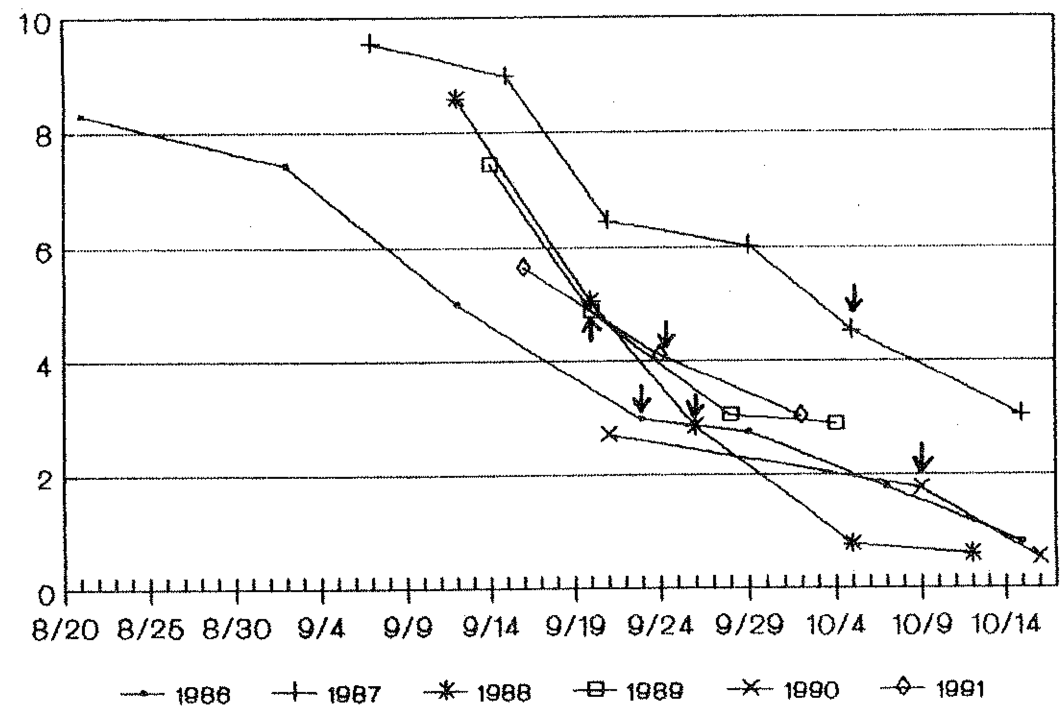
Harvest Index II cv.MacSpur



Harvest Index I cv.Jonathan



Harvest Index II cv.Jonathan



Short Translation

Prediction of the Climacteric Phase of Apple Fruit by testtreatment of the Ethylensynthesis (by Propylen treatment).

P. Quast, D-Jork

Investigations with ethylenanalysis for determination or prediction of climacteric rise in apples were done up to now with apples enclosed in streaming or static atmosphere and controlled periodically on their ethylene release. There are 3 disadvantages:

1.) In combined samples one or few ripe outriderfruit can override the reaction of main sample with no or low ethylene.
2.) If apples are more far from climacteric rise, the reactiontime to ethylenproduction will be more than 10 days which shortens predictiontime.
3.) Detached apples develop earlier an ethylenproduction than attached fruit, so that detached test fruit differ in their behaviour from those remaining on the tree by mechanism of the free factor.

The use of propylene to force the reaction has the advance to be distinguished by GC from natural ethylene. In streaming air (1 Vol per hour) there is no triggering from fruit produced ethylene to other testfruits.

Material and Method

In 1988 to 1991 apples of different varieties and locations were picked in weekly intervals: 20 fruits for IEC (Internal ethylene concentration), starch degradationindex (1 = no; 10 = total degradation) and 20 fruits in 30 ppm propylene and 20 fruits in 250 ppm propylene each for 3 days in 18°C (3T30 and 3T250). Ethylene acts 130fold than propylene on stimulation of ethylene synthesis. So 30 ppm propylene correspond to 0,25 ppm ethylene level and 250 ppm propylene to 2 ppm ethylene. After 3 days the air of the core cavity is analized on ethylene in the same way than fresh picked fruit and results are drawn to picking day.

Results

No variety except 'Elstar' had an increase of IEC before optimal picking date for long term storage if attached to the tree. In 'Cox Orange Pippin', 'Holsteiner Cox', 'Ingrid Marie' and 'Boskoop', which are early varieties for storage, 30 ppm propylene for 3 days were sufficient to give a reaction of more than 0,8 ppm ethylene 12 to 18 days before optimal picking date. Medium storage varieties as 'Golden Del.', 'Jonagold' and 'Ingol' need 3T250 as propylene treatment to give only 6 to 9 days earlier reaction (0,8 ppm ethylene) before optimal picking. In fig. 3 and 4 with 'Boskoop' as well fig. 2 with 'Cox Orange' one can see decreasing ethylene production. This is associated with reduced increasing rate of starch degradation and also poor increase of red coloration over several days, which means fruit remain in a more steady state on their way to final riping for several days. This could be due to intermitted and limited re expanding of "tree factor" in the balance to "riping capacity", may be induced by climatic or weather circumstances.

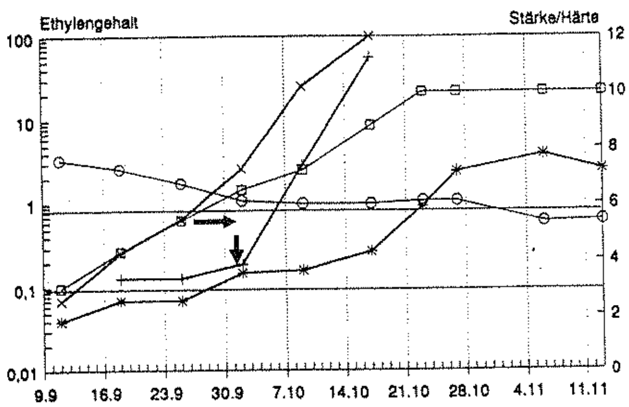


Fig. 3

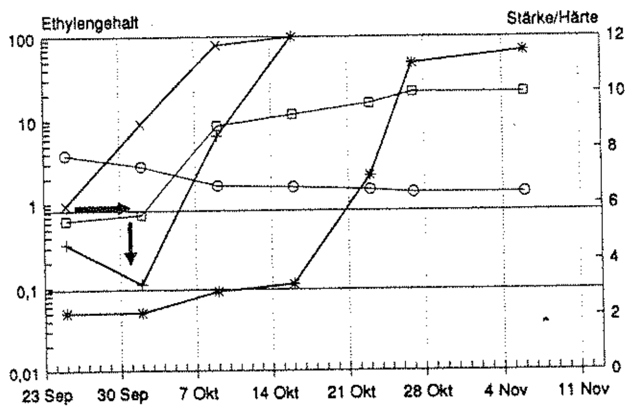


Fig. 4

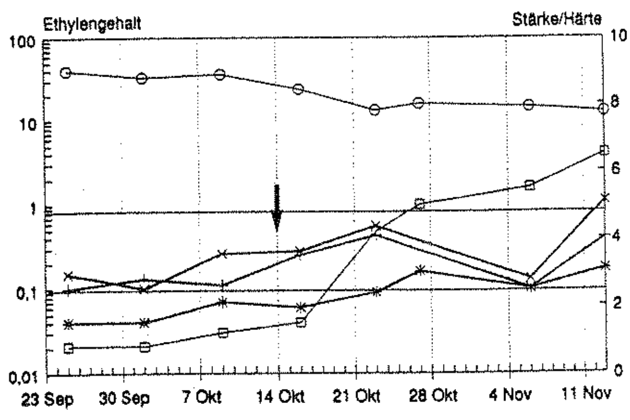


Fig. 5

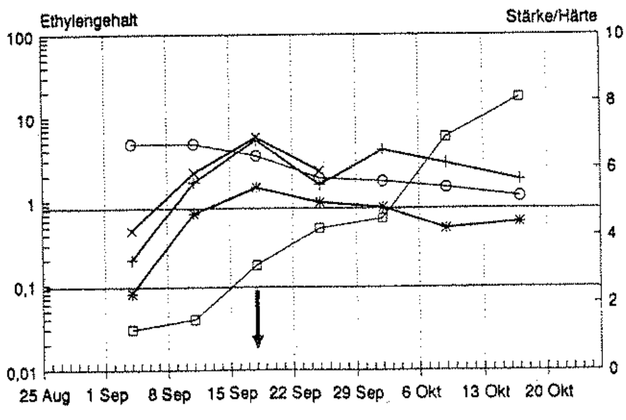


Fig. 6

Fig. 1-6: Development of starch degradation -[]- (Index 1-10), fruit firmness -o- (kg/cm²) and ethylen concentration in core cavity -*- (IEC ppm) attached to tree and influence of 3 days test treatment on ethylenconcentration by 30 ppm propylene -+- and 250 ppm propylene -x- in fig. 1 'Cox Orange', fig. 2 'Boskoop', fig. 3 'Jonagold', fig. 4 'Golden Delicious', fig. 5 'Gloster' and fig. 6 'Elstar'. (Vertical arrow = harvesting date for CA/ULO-storage).

K.NARDIN - AGRICULTURAL RESEARCH INSTITUTE "LAIMBURG" - BOLZANO - ITALY
K.FRASNELLI

APPLE MATURITY PROGRAMME IN SOUTH-TYROL

THE ROLE OF ETHYLENE IN FRUIT MATURITY INDEXING

INTRODUCTION

In 1968 started the maturity programme in South-Tyrol and its main aim was to individuate the F.A.H.D. (First Acceptable Harvest Date), i.e. the apple maturity state that guarantees its keepability, meant in organoleptic and biological terms (physiological ang fungal disorders included).In Europe the concept of the optimal harvest date for storage evolved over the years. This as a consequence of a more precise request of "internal quality" from the consumers and of the advent of more more sophisticated storage technics which allow very good storage results even with fruit picked in a more advanced maturation state than in the past. Anyway the choice of the right harvest time is the result of a series of compromises that takes into account the fruit physiological maturation, the market-aspects (color, size, etc.) and not least the picking capacity of the grower. If in the past some problems were solved thanks to chemical products (as Ethrel, Alar, Giberelline, cosmetic products), today the criticism involves beside these, some other products used in post-harvest, of more traumatic renunciation, like the antioxydants, D.P.A., ethoxyquin and fungicide like Thiabendazol and Benzimidazol. The maturity programm, which wasn't so careful of this aspect at the beginning, must now give new and more precise answers in relation to the existing correlations among ripening at harvest, type and duration of the storage, sensibility to the scald, rotting, "bitter pit" and internal brown core of the different apple varieties. Considering very important at this concern the identification of the beginning of climacterium as a more objective physiological status than the conventional one, the Research Institute in Laimburg began in 1986 a series of tests on all apple varieties to ascertain fruit climaceterium through I.E.C. (Internal Ethylene Concentration) analysis on single fruit samples and to look for a possible correlation with the starch test, usually adopted by single local fruit-growers, or by the cooperative and the Advising Service.

MATERIALS AND METHODS

The apple sample to be submitted to the maturity tests consisted of 10

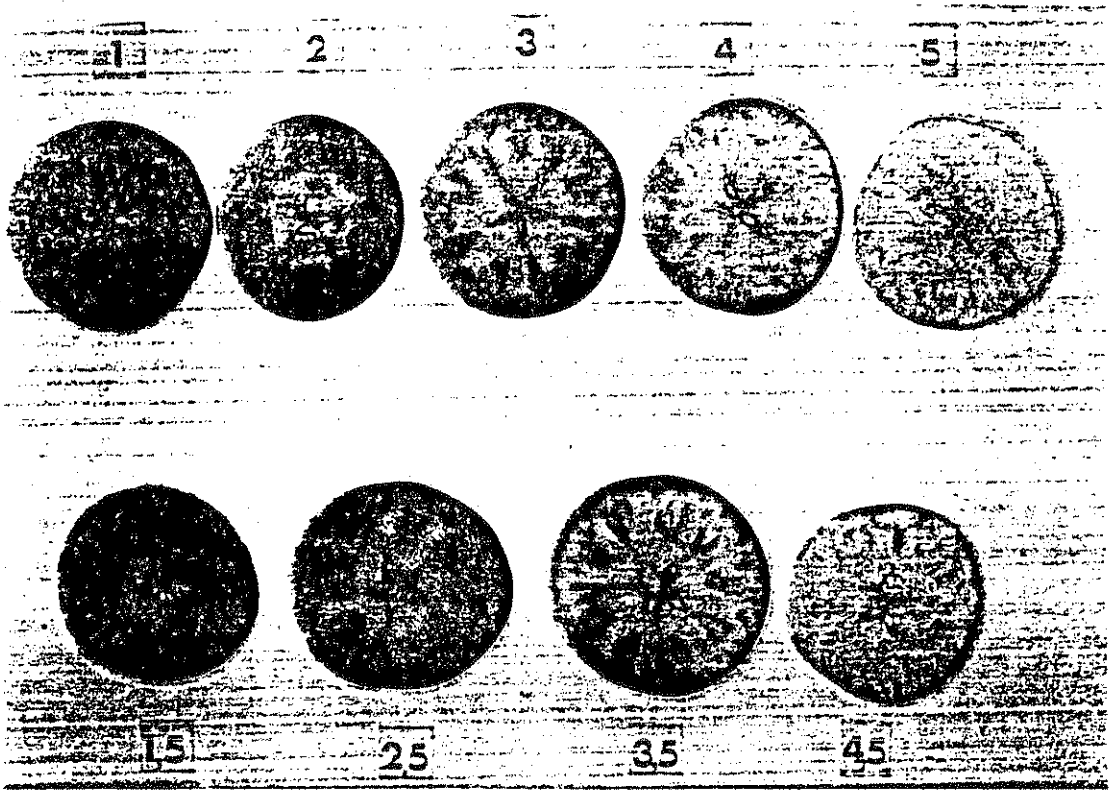
firmness-increase. Years with a dry course do not present wide fluctuations or value alternations.
The amplitude of firmness-decrease during ripening is related to variety, year and growing conditions.
We consider the firmness value in the practical and experimental experience for the apple, unlike what happens for pears, more an organoleptic and qualitative parameter than a true index of the physiological ripening state at harvest, this is proved by the fact that there is no significant relation between this and starch rate and I.E.C..
In spite of this the fruit firmness continues to be an important index for maturity/quality, because it becomes a limiting-factor in post-storage for some apple cultivar (Elstar, Jonagold, Golden, etc.) in organoleptical terms, and from the manipolation sensibility and rot development point of view.

The increase of sugar content, expressed in total soluble solids tab., pointed out wide fluctuations not always explanable in climatic terms (water) or as consequence of the starch conversion (much more linear). We normally record a later sugar decrease in fruits on the tree about 2 weeks after climacterium has begun or after significan precipitation (more than 20 mm). In the maturity-programme a minimum sugar content is indicated for F.A.H.D., which depends on variety and year, but the difference in sugar, with equal starch rate, among apple samples of diffrenet locations turns out to be relevant, related to the nutritional state of the fruit (exposure, soil, crop-load, position on the tree, etc.)
There are physiologically ripe fruits with a poor content of sugar, and some others still physiologically unripe with higher sugar rates, this is to indicate that the content of sugar at harvest can particularly be adopted as index of quality more than of ripening. Our practical experience points out the fact that shadow and underdeveloped fruits (size below 65 mm), even if they reach at harvest the requested minimum sugar content (when starch conversion has already taken place) are difficult to be stored, poor in taste, aroma and firmness. This organoleptic effect turns out to be very important for some aromatic varieties and it is not only and always related to the climatic condition during the development of the fruit.

STARCH AND ETHYLENE: Many fruits enter the climacteric soon after harvest, whereas they might not ripen for weeks if left on the tree. For the apples the climacteric rise of respiration during the ripening on tree is

./.

Smith ,a variety which is particularly prone to scald.
The correlation between I.E.C. and starch rate wasn't significant (the only exception is Red Delicious).
In correspondence of the beginning of the climacterium there was no clear increase in starch conversion. Measurements of I.E.C. can establish whether apples are in pre- or postclimacteric state. It is possibly incorrect to regard a given concentration as making the same physiological state whenever it occurs, since ethylene is only one of a number of factors regulating ripening.
I.E.C. test has pointed out remarkable limits in our study to be identified in strong individual fluctuation for the single apple of the sample; in interpretation difficulties of the climacterium for some varieties, in analytical interferences with strange alternating values.
Nevertheless we still consider useful I.E.C. test, concentrating the research on those varieties, which are prone to scald, and for which the right harvest date is determining.
We are still sceptical about the employ of this test as a generic criterion to separate the various lots destined to storage of different duration, as it was suggested by some experts in U.S.A, also because of the laboriousness of the analysis method.
According to us for a correct judgement on a fruit-ripening it is still necessary a combination of factors, among which starch is the most important. We hope that in future this value gains a more correct and less subjective reading (instrumental determination).
Furthermore, factors other than, or in addition to maturity at harvest will determine the storage keeping quality of apples.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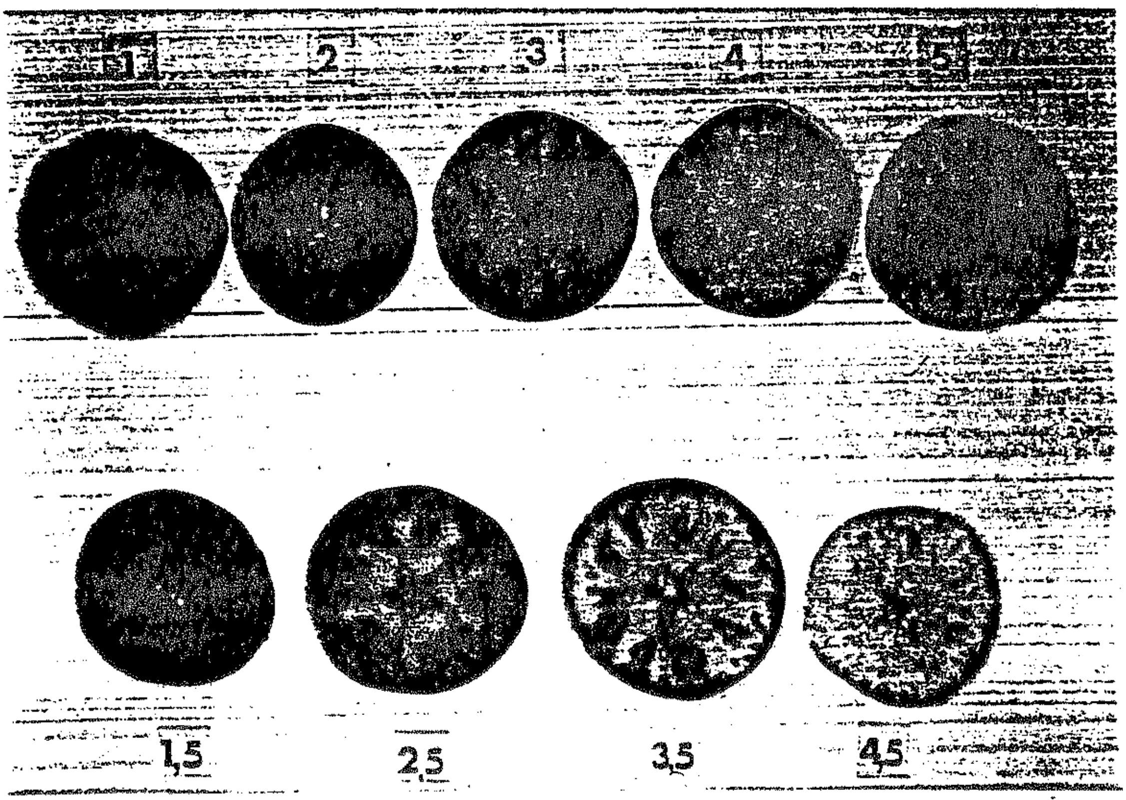
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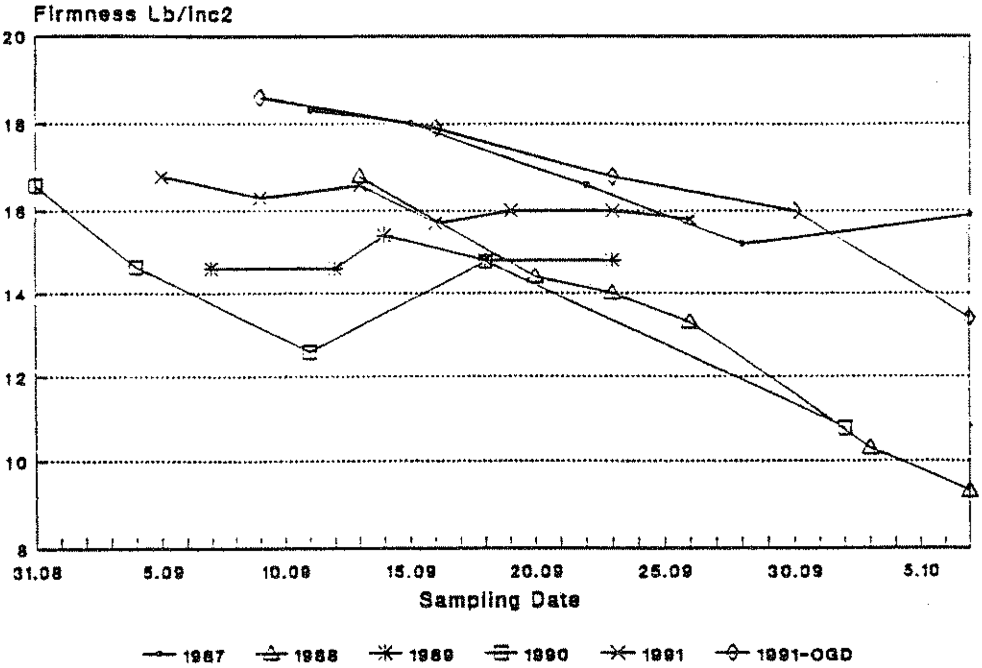
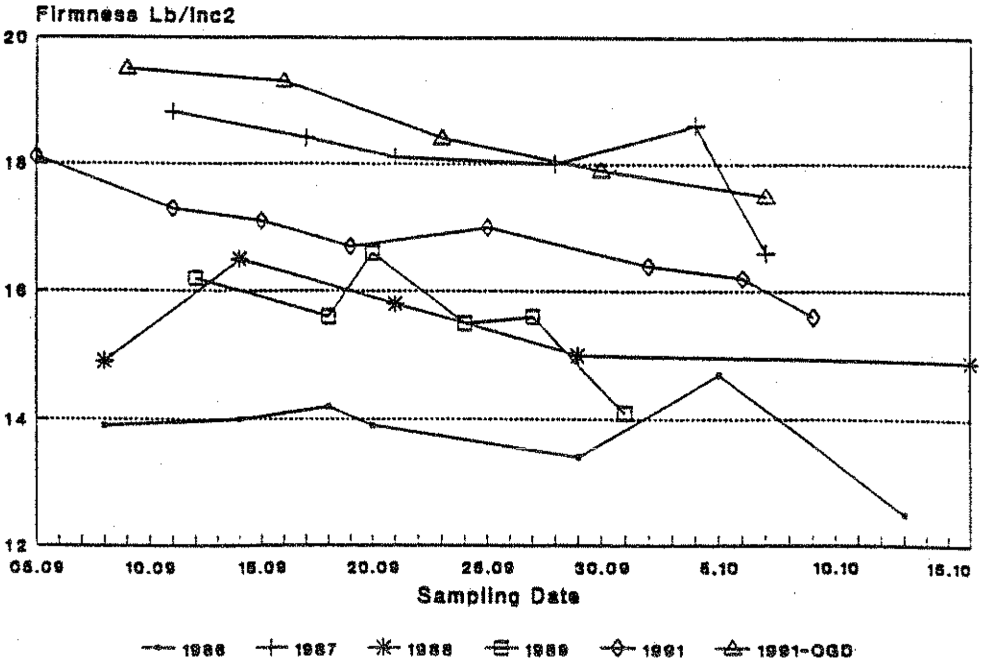
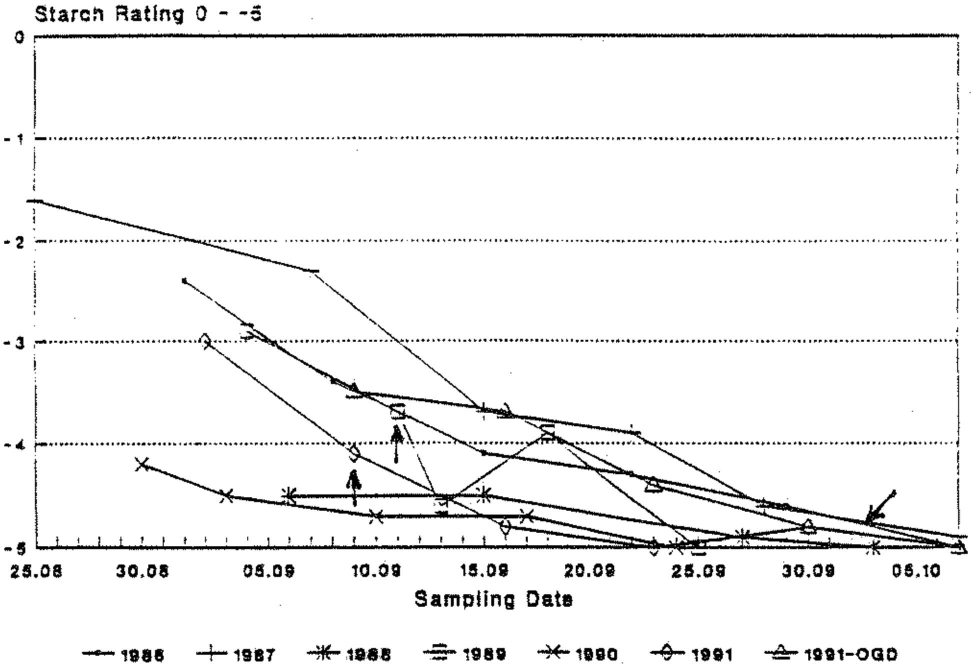
STARK: FIRMNESS CHANGES DURING MATURATION



GLOSTER: FIRMNESS CHANGES DURING MATURATION



JONAGOLD: STARCH CONVERSION DURING THE FRUIT MATURATION (↗:climacteric begin)



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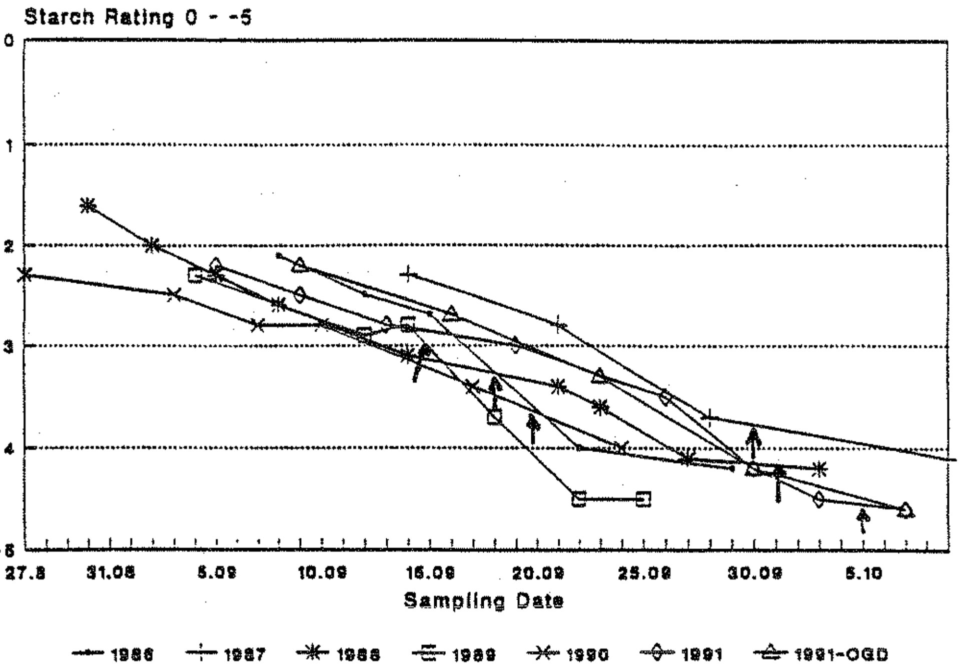
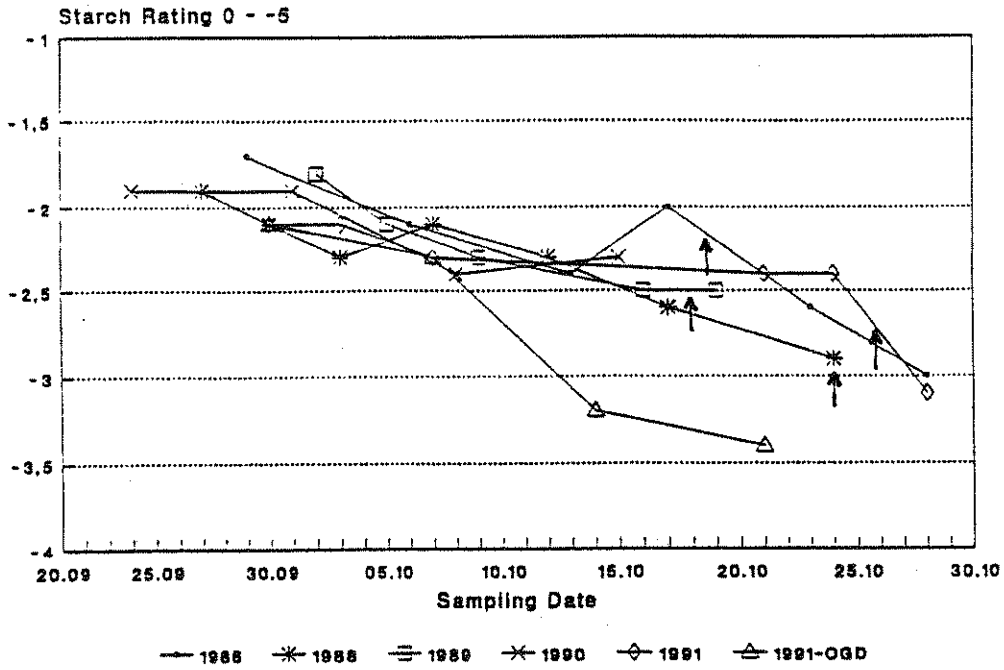
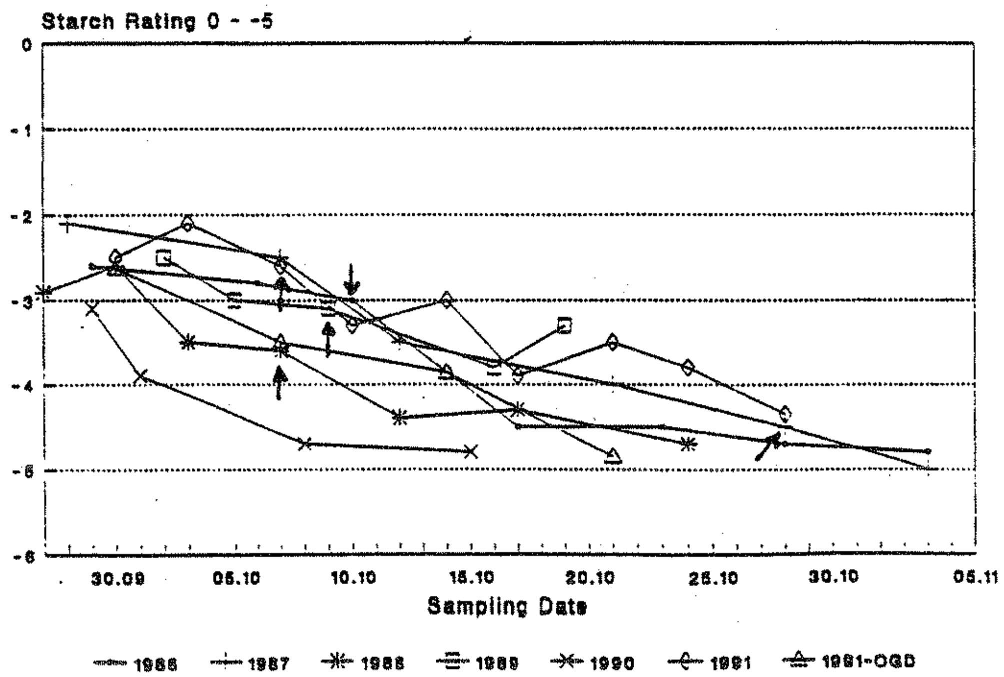


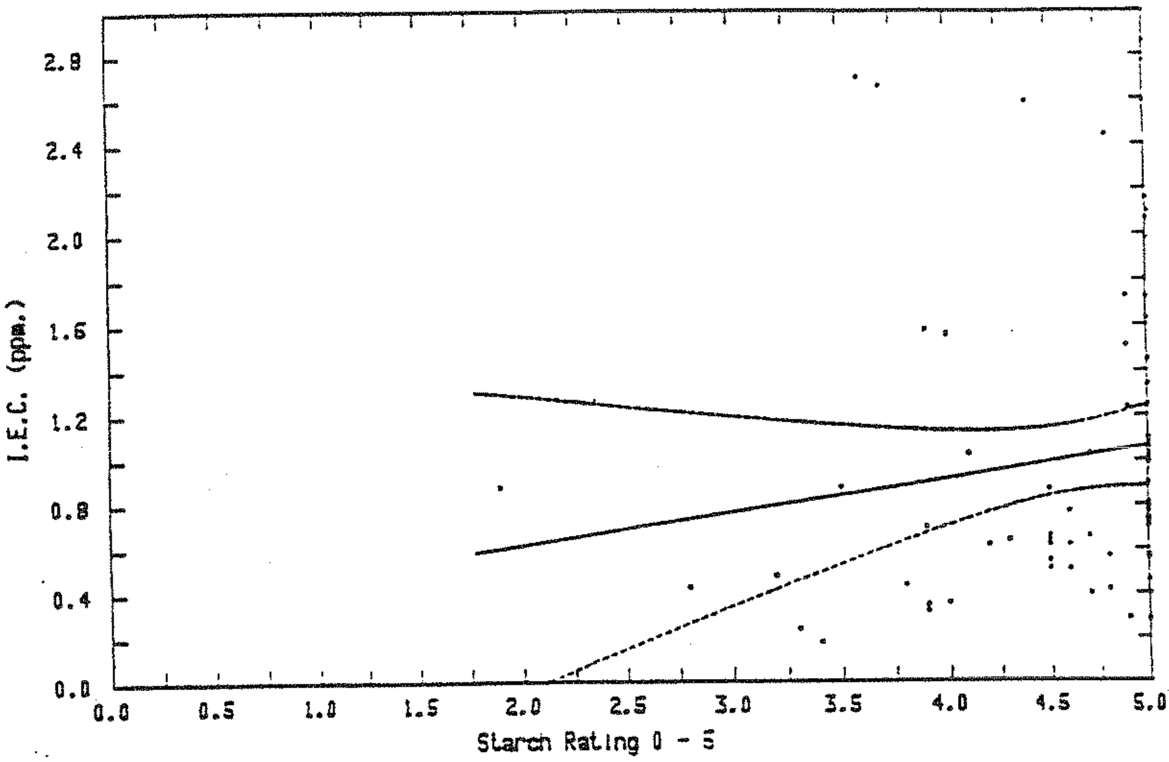
GRANNY: STARCH CONVERSION DURING THE FRUIT MATURATION (↗:climacteric begin)



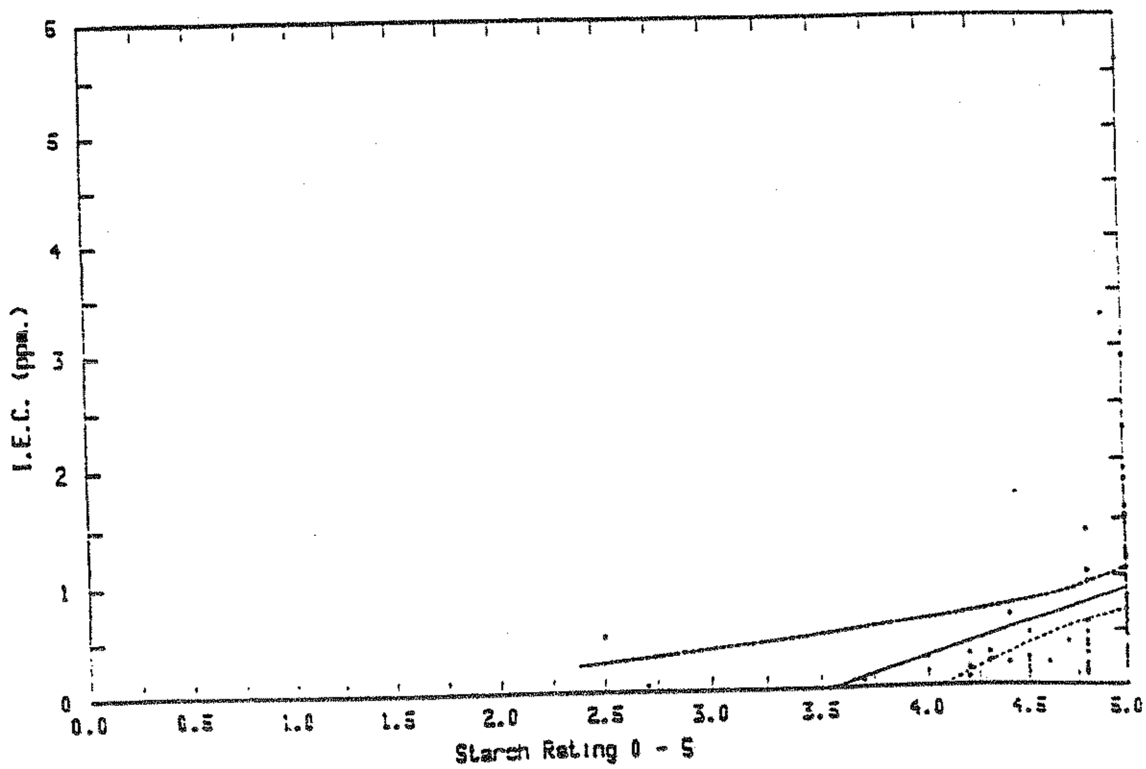
MORGENDUFT: STARCH CONVERSION DURING THE FRUIT MATURATION (↗:climacteric begin)



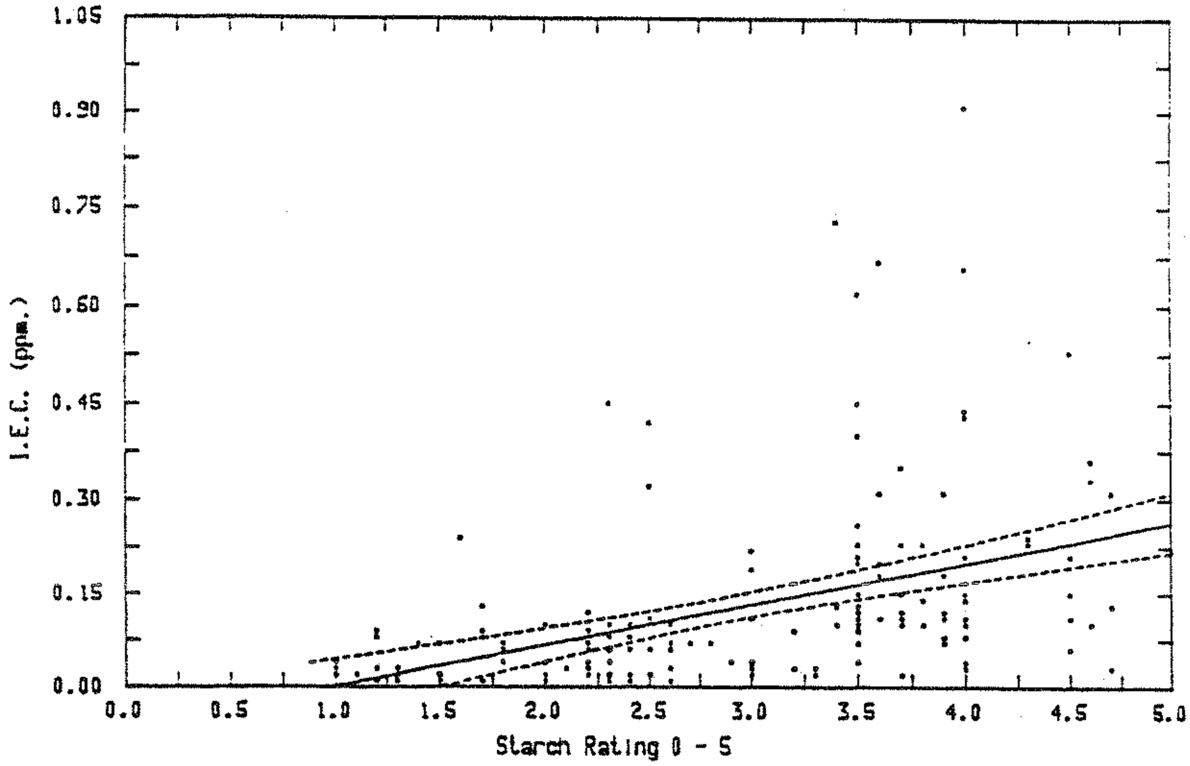
CORRELATION BETWEEN STARCH RATING AND I.E.C.
JONAGOLD - LAIMBURG 1988



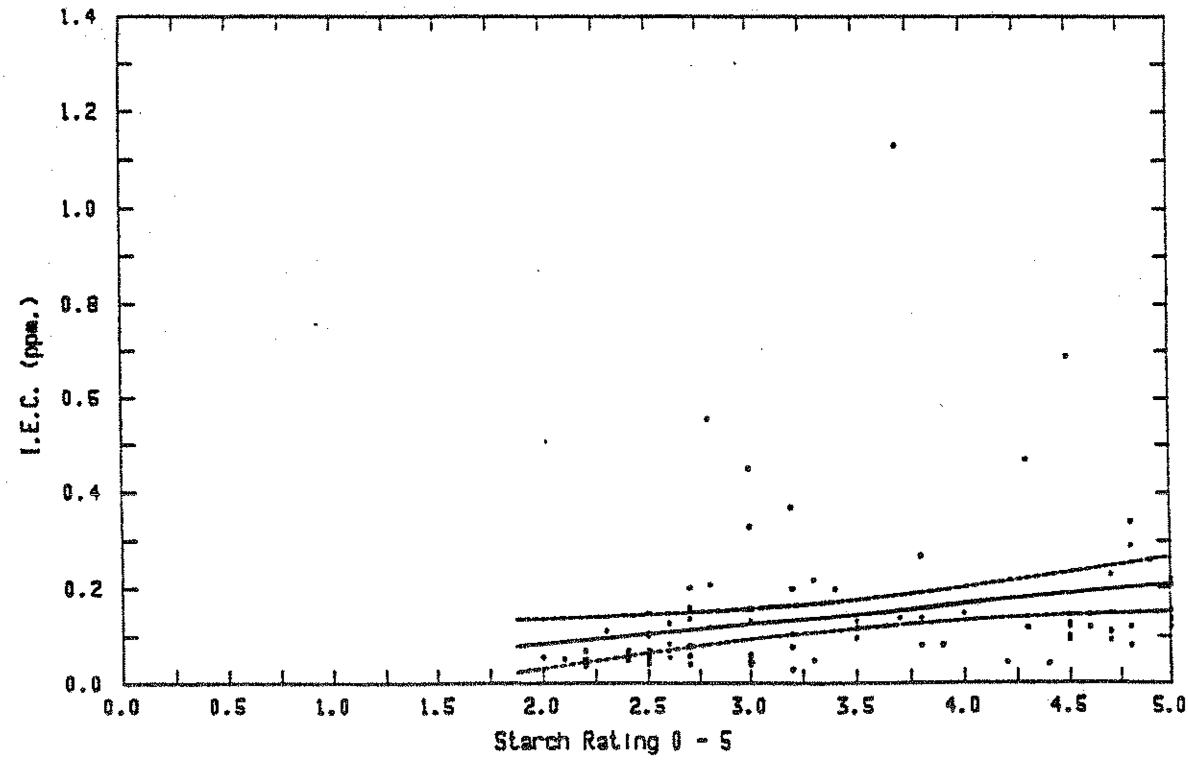
CORRELATION BETWEEN STARCH RATING AND I.E.C.
JONAGOLD - LAIMBURG 1991



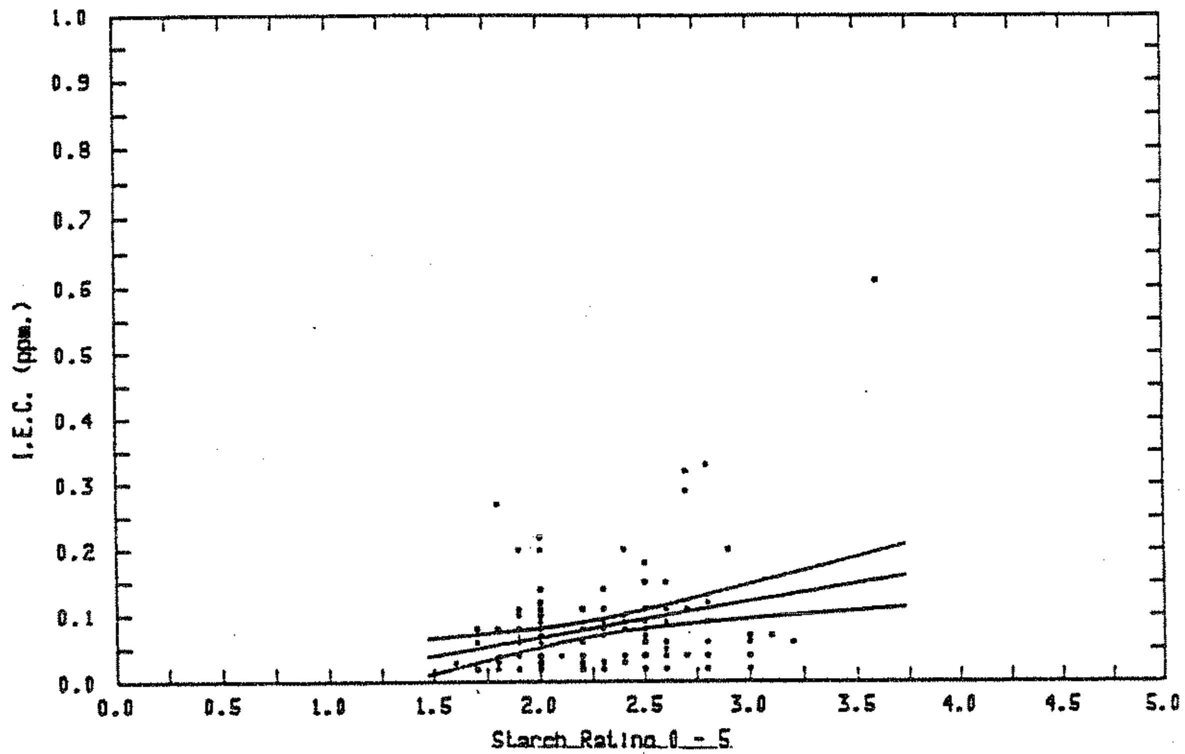
CORRELATION BETWEEN STARCH RATING AND I.E.C.
GOLDEN - LAIMBURG 1988



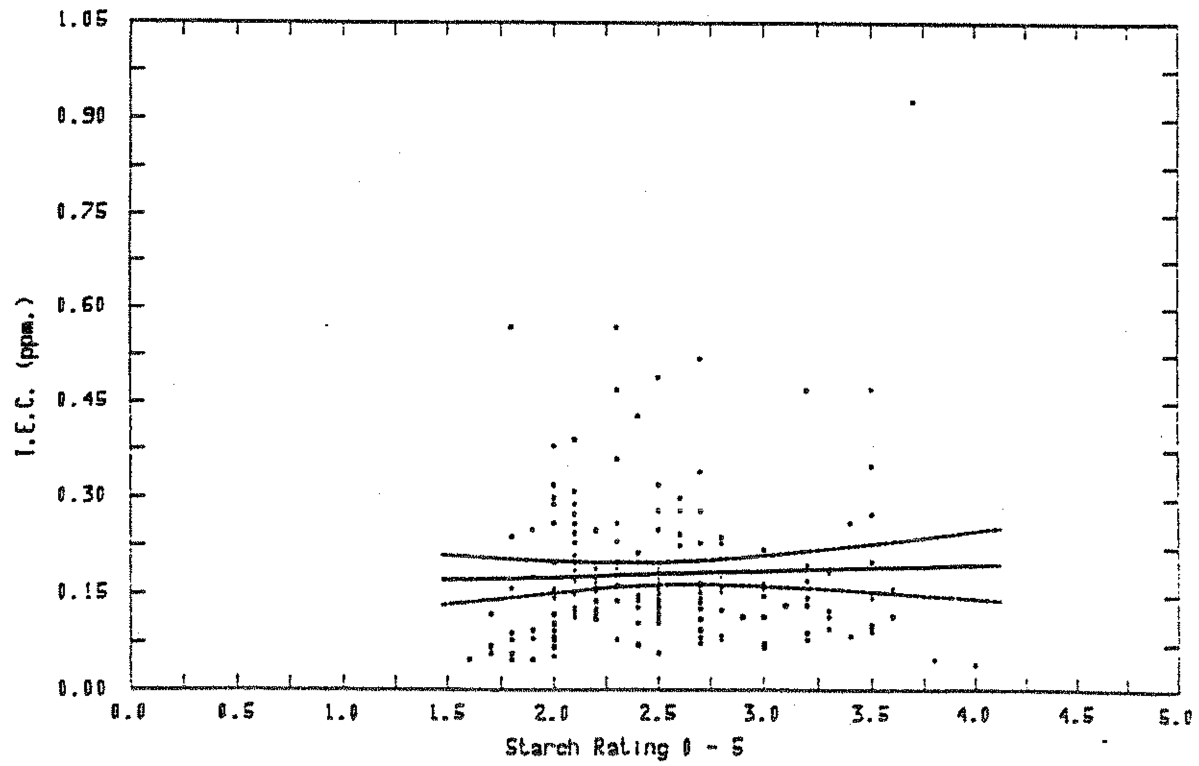
CORRELATION BETWEEN STARCH RATING AND I.E.C.
GOLDEN - LAIMBURG 1991



CORRELATION BETWEEN STARCH RATING AND I.E.C.
GRANNY SMITH - LAIMBURG 1988



CORRELATION BETWEEN STARCH RATING AND I.E.C.
GRANNY SMITH - LAIMBURG 1991



FIRMNESS - TEST ON APPLE

COMPARATION BETWEEN VALUES OBTAINED WITH A HAND-PENETROMETER (EFFEGI - ALFONSINE - ITALY) AND A ELECTRONIC PRESSURE TESTER (LAKE CITY TECHNICAL PRODUCTS - CANADA)

LAIMBURG, 14.05.1991

VARIETY	METOD USED	OPERATOR 1		OPERATOR 2		OPERATOR 3		OPERATOR 4	
		Lb/inc 2		Lb/inc 2		Lb/inc 2		Lb/inc 2	
		AVERAGE	S. DEV.	AVERAGE	S. DEV.	AVERAGE	S. DEV.	AVERAGE	S. DEV.
MORGENDUFT	H.P.	15,17	1,13	14,25	0,61	15,37	1,26	16,52	1,62
	E.P.T. *	15,78	1,25	14,90	1,13	15,10	1,19	15,33	1,43
	MEAS. ERR.*	0		1		1		1	
GRANNY SMITH	H.P.	14,39	0,70	13,76	0,68	14,58	0,90	14,93	0,91
	E.P.T. *	14,35	0,85	13,91	0,71	13,80	0,64	13,97	0,96
	MEAS. ERR.*	0		0		5		1	
GOLDEN DELICIOUS	H.P.	12,72	0,62	13,33	1,07	11,64	2,52	12,82	0,87
	E.P.T. *	13,77	1,08	13,36	2,38	13,05	1,36	12,63	0,53
	MEAS. ERR.*	1		2		2		1	
JONAGOLD	H.P.	9,30	1,08	10,26	0,69	10,17	1,06	10,64	0,71
	E.P.T. *	10,22	1,20	11,14	1,32	10,01	1,50	9,88	1,01
	MEAS. ERR.*	2		0		1		0	
RED DELICIOUS	H.P.	10,02	1,20	11,59	0,93	10,87	0,80	11,87	0,62
	E.P.T. *	10,41	1,10	11,82	1,29	10,51	0,87	11,33	0,70
	MEAS. ERR.*	1		0		6		1	

ariety	Jonathan			Golden			Jonagold			Stark Del.			Gloster			Morgenduft			Granny S.		
F.F.B.	135 - 139			138 - 142			142 - 146			143 - 147			147 - 150			165 - 168			169 - 171		
ear	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days	Bloom Date	Clim. Date	Days
1986	28.04	08.09	134	28.04	18.09	144	25.04	-	-	28.04	-	-	28.04	-	-	02.05	10.10	162	28.04	19.10	175
1987	27.04	11.09	138	27.04	30.09	157	24.04	-	-	27.04	15.09	142	27.04	07.10	164	27.04	28.10	185	27.04	-	-
1988	20.04	29.08	131	22.04	01.10	163	20.04	-	-	20.04	13.09	147	22.04	11.10	173	22.04	07.10	169	22.04	24.10	186
1989	17.04	-	-	19.04	15.09	150	17.04	11.09	148	-	12.09	-	21.04	22.09	155	-	09.10	-	17.04	18.10	185
1990	09.04	-	-	09.04	20.09	165	09.04	-	-	-	03.09	-	12.04	-	-	17.04	-	-	09.04	-	-
1991	12.04	05.09	146	15.04	05.10	174	12.04	09.09	151	12.04	13.09	155	12.04	19.09	161	15.04	07.10	176	12.04	26.10	198

Prediction of the Optimum Harvest Date for Cox Orange Pippin apples using a fitted meteorological model

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Abstract

A model has been developed for prediction of the optimum harvest date of Cox Orange Pippin apples using 18 years of data of full bloom, harvest date, temperature and precipitation with 82.5% of the variance accounted for.

For the Wilhelminadorp location precipitation appears to be an important factor in addition to temperature. Applying this model to the data of 1992 reveals a complicated effect of especially precipitaton. The model apparently underestimated the effect of this factor in early summer but overestimated it towards the end of the period of fruit development.

Introduction

Several methods have been developed to estimate the optimum harvest date (OHD) of apples. Some of these methods are based on human expertise (e.g. Washington Stage Apple Maturity Program) some are semiquantitative, like the T-stage method by Stoll (1968) and some try to describe the relationship between fruitparameters and time (see this workshop) or between development period and meteorological data (Luton and Hamer, 1983). These relationships could then be used as a model to predict OHD. A meteorological model would offer the advantage of a relatively simple application e.g. by growers who have a weather recording station and a PC at their disposal. On the other hand fitting a model requires relatively much time. This paper describes the fitting of harvest date of Cox Orange Pippin to date of full bloom, temperature and precipitation for a period of 18 years at one location.

Methods

Data of full bloom (FB), temperature and precipitation and OHD for the variety Cox Orange Pippin, collected at the location Wilhelminadorp, were used to fit a model of OHD. Data of temperature (mean, maximum, minimum) and precipitation are available on a daily basis. The data refer to trees of 4 years age and older that are part of a variety trial. Decision on when to pick the fruits were each year taken by the responsible scientific officer. Fitting was stepwise executed by the so-called R-select method. Mean 24 hours temperature and daily precipitation were introduced on a monthly basis.

Results and Discussion

Introducing more variables increased the %variance accounted for, but also increased the complexity of the formula.
The following relationships have been found:

(1) ND = -0.838 FB + 166.1
% variance accounted for 40.8% (adjusted R2 = 37.1%)

(2) ND = -1.033 FB - 0.1518 DIF(May) + 211.8
% variance accounted for 61.7% (adjusted R2 = 56.6%)

(3) ND = -1.219 FB - 0.1602 PR(May,June,July,August) + 0.3059 PR(June) - 0.2262 DIF(May) - 0.2044 DIF(July) + 305.5
% variance accounted for 82.5% (adjusted R2 = 72.9%)

where ND = number of days from Full Bloom to OHD
FB = days from April 1 tot Full Bloom
PR = average of daily precipitation
DIF = average of difference between maximum and minimum temperature

The predicting behaviour of equation (3) for the dataset of the growing season of 1992 in relation to the actual weather is demonstrated in figure 1. The prediction is based on using the standard data set (mean for the 18 years used to fit the model) and replacing the standard data by the actual data on a daily basis.

Figure 1b shows that after the period of 6 weeks the prediction concords well with the actual OHD which occured at September 3, 121 days from FB (according to the Streif method).
Retardation of predicted OHD in the following period seems to be related to higher amounts of precipitation. In contrast, higher amounts of precipitation at the end of the growing period seems to advance OHD.
In general DIF follows the same curve as the maximum temperature. Maybe the occurrence of cold nights in May causes DIF to be a better variable than maximum temperature. During May and July DIF was higher than normal. During these periods predicted OHD was clearly advanced

Collectioning of data is going on already for 3 years and will be continued the coming years on 4 locations distributed over the country for the varieties Cox Orange Pippin, Elstar and Jonagold.

Literature

Luton M.T. and P.J.C. Hamer (1983), Predicting the optimum harvest dates for apples using temperature an full bloom records. Journal of Hort. Science 58:37-44.

Stoll K., F. Hauser and D. Daetwyler (1968), Unterschiede zwischen morhpologischer Fruchtentwicklung und physiologischer Reifung beim Apfel. Schweiz. Zeitschrift fur Obst- und Weinbau 104:641-645

Fifty to sixty untrained panelists participated in each test. Each panelist was presented six pieces of unpeeled apple in random order from different harvest dates. The panelists were asked to rate their preference on a 9 point hedonic scale (1=dislike extremely, 5=neither like or dislike, 9=like extremely). They were also asked to be descriptive about the samples, and rate from 1 to 9 (1=low, 9=high) for the intensity perceived of firmness (crunchiness), sweetness, tartness and apple flavor. The tests were conducted in booths illuminated with red light so panelists could not identify any change in fruit color.

Apples were held four days at room temperature before testing to simulate shelf life. Each fruit was also measured for firmness prior to serving, and soluble solids content and titratable acidity of an aliquot of juice.

Statistical analysis

Analysis of variance and correlations were run on each fruit attribute in the maturity and storage study using the Statistical Analysis System (SAS Institute Inc., Cary, NC). The ANOVA and correlations of treatment effects were tested for each tasting session. Correlations were run between sensory ratings and analytical measurements for each sub-sample.

CONCLUSION

The release of harvest based on the modification of the rate of change of some maturity indices as practiced by the Washington State maturity program (Olsen, 1982) revealed to be correct for the new apple cultivars 'Gala', 'Braeburn' and 'Fuji' in 1991 and under the Pacific Northwest conditions. Assessing the optimum picking date for a given length of storage was possible with consumer taste tests. Late harvests were preferred on the early taste tests. The longer the apples were stored, the narrower was the window for harvesting.

'Gala' physiological maturity was attained at 122 DAFB (26 Aug) for long-term storage (January). At that stage, SI was highly variable, SSC was at 11° Brix and ethylene production was 1 ppm at harvest, but fruit color was not fully developed.

Fruit of 'Braeburn' picked 168 and 175 DAFB (10 and 17 Oct 1991) had the best storage potential (April in regular storage). SSC and a* value of the ground color were the most obvious parameters on which to release harvest date in 1991. Internal ethylene showed the autocatalytic rise after 7 days ripening early in season. Starch index increased with a great variation 175 DAFB (17 Oct). Late harvest fruits expressed a nutrition disorder as corky spots in the flesh on 10% of the fruits. More study is required on 'Braeburn' as to maturity indices and mineral nutrition.

Internal ethylene could not be used as a physiological indication of 'Fuji' maturity in 1991, since it stayed at low levels and without autocatalytic production. The only reliable predictors were the starch index, which increased suddenly and with a great variability 173 DABF (14 Oct).

Leuven, 28 August 1992

VARIABILITY IN MATURITY, QUALITY AND STORAGEABILITY OF JONAGOLD APPLES ON A TREE

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3000 LEUVEN (Belgium)

Abstract

We found that the variability in maturity and quality at a certain picking date of Jonagold apples on the same tree is very important. Data are given on the variation in starch content, firmness, green-yellow skincolour, Brix value and fruit weight.
The variability in maturity makes it necessary to pick at different times. The quantity to be picked at each picking time varies between 2.5% (1st picking time), 25.7% (2nd), 42.4% (3rd), 22.4% (4th) and 1.9% (5th)
Values of indices are given to determine optimum maturity characteristics at each picking time. For the first picking time a starch content of 50-60% dark surface with a firmness greater than 7.5 lbs (0.5 cm²) is important.
At the last picking time the optimal picking occurs at an optimum starch content of 40-50% dark surface and a sufficiently green ground colour (lower than 7).
In literature some interpretation is given of the variability in maturity of the Jonagold apples on a tree.

1. Introduction

At an early picking time, fruits are insufficiently developed, the sugar content and aroma are low and fruits are more sensitive to scalding. Late picked fruits are yellower and softer and more sensitive to internal breakdown (low temperature breakdown).
When all Jonagold apples on a tree are not ripe at the same moment, picking at different times - interpicking - will be necessary. Concerning this question, the following aspects are studied :

- How high is the variability in maturity and quality of the fruits on a tree
- What are the most practical indices for determining which apples are to be taken out at each picking time
- What are the physiological origins of the observed variability
- How to reduce the variability in maturity and quality by cultural practices (pruning, chemical thinning, planting systems).

We also observed that after storage, fruits affected by scalding are equally hard but more yellow than sound fruits and that fruits affected by internal breakdown are softer and yellower than sound fruits.

220 g/fruit and higher. Fruits to be separated at the latest picking time have a colour stage higher than 7.
For practical reasons we can reduce the picking time from 5 to 3 by separating some improper fruits for long time storage using the above mentioned indices.

3. Discussion

Practical indices for Jonagold apples, indicating the quantity of fruits to pick at each picking time, are given that are to be used by growers.

In literature some explanation is given of the physiological origin of this variability (D.R. Dilley, equilibrium plant-growing substances; G.B. Blanpied, C.R. Little, differences in flowering date; H.L. De Pooter, N. Schamp anabolic-catabolic equilibrium; R. Marcelle soluble calcium content).

Now we are studying the variability in maturity and storageability for other varieties and mutants and also for Jonagold apples, cultivated with special cultural practices such as planting systems and pruning, in order to obtain a more homogeneous product on the tree.

References

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- De Pooter, H.L., Schamp, N., 1989. Involvement of lipoxygenase-mediated lipid catabolism in the start of the autocatalutioc ethylene production by apples (c.v. Golden Delicious) : a ripening hypothesis. Acta Horticulturae, n° 258, Dec 1989 : 47-54.

- D.R. Dilley, 1969. The control of fruit ripening. Hort. Science, 4, 1969 : 111-114

- R. Marcelle. Soluble la content in apples (Personal information).

Starch Content
(% fruits for each starch stade)

1991

stade	23/9	4/10	11/10	18/10	25/10
1	14.5	0.0	0.0	0.0	0.0
2	49.4	11.0	0.0	0.0	0.0
3	28.9	19.5	0.9	0.0	0.0
4	6.0	29.5	0.5	0.6	0.0
5	1.2	25.0	4.5	0.6	0.0
6	0.0	10.5	17.7	4.0	0.5
7	0.0	2.0	48.2	19.2	1.4
8	0.0	0.5	18.6	52.5	15.7
9	0.0	1.5	8.2	22.0	69.0
10	0.0	0.5	1.4	1.1	13.4

1992

stade	21/9	28/9	5/10	12/10	19/10
1	0.0	0.0	0.0	0.0	0.0
2	1.5	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	10.8	0.9	0.0	0.0	0.0
5	27.7	0.9	0.0	0.0	0.0
6	27.7	9.4	10.0	1.8	0.0
7	18.5	28.3	35.0	3.6	0.0
8	7.7	41.6	37.5	7.3	0.0
9	4.6	15.1	17.5	32.7	38.7
10	1.5	7.8	0.0	54.6	61.3

Firmness
(% fruits for each firmness range)

1991

Firmness range	23/9	4/10	11/10	18/10	25/10
5.5 - 6.4	0.0	0.0	1.0	2.3	0.5
6.5 - 7.4	6.0	8.0	4.5	20.4	18.0
7.5 - 8.4	22.9	39.0	37.8	49.6	45.8
8.5 - 9.4	25.4	34.5	35.8	18.1	26.4
9.5 - 10.4	27.7	9.0	15.0	7.9	5.1
10.5 - 11.4	9.6	8.5	5.0	1.7	3.7
11.4 - 12.4	1.2	1.0	0.9	0.0	0.5

1992

Firmness range	21/9	28/9	5/10	12/10	19/10
5.5 - 6.4	4.6	0.9	0.0	9.1	0.0
6.5 - 7.4	53.9	26.4	32.5	47.3	8.7
7.5 - 8.4	38.5	45.4	35.0	32.7	45.2
8.5 - 9.4	3.0	21.7	32.5	10.9	32.3
9.5 - 10.4	0.0	3.8	0.0	0.0	12.8
10.5 - 11.4	0.0	1.8	0.0	0.0	0.0
11.4 - 12.4	0.0	0.0	0.0	0.0	0.0