Pre- and Post-Harvest

The quality and storage efficiency of some apple varieties as a function of picking date, area of production and duration of storage

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Summary: Numerous apple varieties have been tested parallel with traditional Jonathan varieties during four years, 1990-1994 on three different geographical areas of Hungary. The picking time took place at three different times in a year: ten days before the probably optimal picking time, at close-to-optimal picking time, and ten days after the optimal picking time. The effect of storage on quality of fruits have been tested in February, March, and April under circumstances of a semi-industrial storage experiment.
The results of experience can contribute to answer numerous current, from point of view of practice important topics:

- The stochastic relations between various fruit quality parameters at different varieties
- The change of fruit – quality during storage
- The effect of different picking date on storage losses
- The possibilities of storage – loss predicting by the utilization of multiple regression analysis.

The most important results of experiences are as follows :

1. The starch – degradation test and Streiff – index are well applicable for practical purposes to determine the optimal harvest-date.
2. On base of analysis of various losses and physiological diseases the high importance of mass loss is obvious. In the variety Jonnee the earlier picking date considerably increased the mass loss. The effect of variety on mass loss is rather limited. In the Jonathan varieties the Jonathan spot was a rather important physiological disease. The late picking time increased the frequency of Jonathan - spot. At optimal date of harvest at Jonnee the frequency of Jonathan -spot was lower, than at Jonathan M 41. In the Jonathan M41 and Jonnee the importance of scald was rather limited, but in the Wellspur Delicious and Smoothee this disease occurred relatively frequently. In the Smoothee the earlier picking time considerably increased the probability of scald.
3. The multiple regression analysis yielded reliable results, fit for prediction of storage losses and diseases on the base of chemical and physical properties, determined at the time of picking.

Introduction

Fruit storage plays an important role in Hungarian horticulture. The modernization of variety- structure and post - harvest technology is a key question from point of view of increasing competitiveness of Hungarian apple production .

The results of experience can contribute to answer numerous current topics, important from point of view of practice:

- stochastic relations between various fruit quality parameters at different varieties
- change of fruit quality during storage
- effect of different picking dates on storage losses
- possibilities of predicting storage - loss by utilization of multiple regression analysis.

The stochastic relations between various fruit parameters are in the subject of much post - harvest research. Some results published in literature are shown in *Table 1.*

Table 1 Stochastic relations between various quality parameters of apple varieties according to various sources

	QUALITY PARAMETERS		CORRELATION COEFFICIENT	VARIETY
Lott (1961)	soluble solids	fruit mass	0.75	Golden Delicious
		skin coloring	0.61	at picking
	fruit mass	acidity	–0.11 – +0.33	varies as a function of pruning
Bühnemann (1963)	softening	fruit mass	–0.635	Cox Orange
			+0.286	Boscoop
Lévaváry (1972)	flesh firmness	soluble solids	0.01	different varieties, after twomonth-long cool storage
		acidity	0.869	
	soluble solids	acidity	0.125	
Aeppli (1984)	flesh firmness	Thieault index	0.32	results of an analysis of 57 apple varieties
		acid content	0.24	
		sugar content	0,25	
Stolle , Reichel , Schmidt (1985)	fruit mass	days of ripening	–0.55	Golden Delicious
Tomcsányi (1987)	fruit mass	acidity	0.33	different varieties
		soluble solids	0.38	after 1 month cool storage
		flesh firmness	0.54	
	acidity	sugar-acid ratio	0.92	
	soluble solids	sugar-acid ratio	0.52	
		flesh firmness	0.39	

Material and methods

Numerous apple varieties have been tested parallel with traditional Jonathan varieties during four years, 1990–1994 on three different geographical sites of Hungary. The picking time took place at three different times in a year: ten days before the probably optimal picking time, at close-to-optimal picking time, and ten days after the optimal picking time. The effect of storage has been tested in February, March, and April under circumstances of a semi-industrial storage experiment. Fruit parameters, determined at harvest and during storage are shown in *Table 2.*

Table 2 The most important investigated varieties

Investigated variety	Genetical background
Jonathan M41	Jonathan clone
Smoothee	semispur mutant of Golden Delicious
Wellspur Delicious	semispur mutant of Golden Delicious
Jonnee	bud mutant of Blackjohn
Redspur Delicious	spur type of Delicious

The flesh firmness of fruits have been tested by a penetrometer. The firmness have been separately measured on the shady and on the colored side of apples. The analysis of regression underlines that the two values slightly differ at the time of picking (higher values of flesh firmness) but the difference between flesh firmness of apple sides diminished during storage.

Results

The basic characteristics of fruit quality parameters determined at harvest, in February and in April, as a function of picking time are shown in *Table 4.*

Table 3 The investigated properties and their methods of determination

Investigated property	Method of investigation
intensity of covering color	special reference patterns (SASS,1993), empirical scale from 1 to 5 minimal intensity = 1 maximal intensity = 5
ground color	special reference patterns empirical scale from 1 to 10 the values of color increase during ripening
flesh firmness	penetrometer
starch degradation	special reference patterns for determination of starch degradation, based on KJ test starch degradation begins = 1 no detectable starch = 5
acid content	titration, expressed in %
soluble solid content (s.s.c.)	hand refractometer, expressed in %
Indices, expressing the condition of fruits	
Soluble solid content / acid content	
Thiault index	10 * soluble solid content + 100*acidity
Streiff index	flesh firmness / (starch degrad. level * soluble sol.cont.)

The effect of picking time on storage losses are summarised on *Table 5.*

Table 4 Effect of picking time and storage duration on quality parameters of fruits.

Jonathan M41									
	Harvest Picking time			February Picking time			April Picking time		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
ground color (point)	3.6	4.4	5.0	3.8	4.5	5.0	3.9	4.5	5.0
intensity of surface color (point)	4.2	4.6	4.8	4.3	4.7	4.8	4.4	4.9	4.9
flesh firmness (daN/cm²)	9.5	8.6	8.4	5.4	5.1	4.9	4.8	4.6	4.2
soluble solid content (%)	13.1	14.0	15.1	14.1	14.6	15.3	14.3	14.9	15.6
acid content (%)	0.98	0.70	0.62	0.57	0.52	050	0.46	0.43	0.36
starch degradation (point)	2.5	3.6	4.3						
soluble solid / acid content	13.2	19.9	24.1	24.8	27.9	30.7	31.4	37.4	43.8
Thieault index	229	210	213	198	198	203	189	189	192
Streiff index	0.28	0.12	0.08						
Jonnee									
	Harvest Picking time			February Picking time			April Picking time		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
ground color (point)	1.0	3.7	4.1	3.3	3.8	4.2	3.5	3.9	4.2
intensity of surface color (point)	3.9	4.5	4.7	4.2	4.6	4.8	4.7	4.8	4.8
flesh firmness (daN/cm²)	9.8	8.4	8.1	7.2	6.5	6.1	5.4	5.1	4.8
soluble solid content (%)	13.2	13.3	13.4	13.2	13.3	13.4	13.6	13.6	13.5
acid content (%)	0.73	0.65	0.58	0.53	0.51	0.47	0.39	0.43	0.41
starch degradation (point)	2.5	3.8	4.1						
soluble solid / acid content	18.0	20.3	22.7	25.1	25.9	28.6	35.9	31.9	33.3
Thieault index	205	198	192	185	184	181	175	179	176
Streiff index	0.21	0.10	0.08						
Redspur Delicious									
	Harvest Picking time			February Picking time			April Picking time		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
ground color (point)	6.2	6.5	6.8	6.4	6.6	6.9	6.4	6.7	6.9
flesh firmness (daN/cm2)	6.3	5.4	5.2	5.7	5.1	4.8	5.1	4.6	4.3
soluble solid content (%)	13.9	14.4	14.8	14.1	14.6	15.1	13.9	15.2	15.2
acid content (%)	0.39	0.34	0.31	0.28	0.28	0.26	0.22	0.24	0.20
starch degradation (point)	2.5	3.4	4.0						
soluble solid / acid cont.	35.5	41.7	46.6	50.7	53.1	57.2	63.5	64.4	76.4
Thieault index	178	178	179	169	175	177	161	176	172
Streif index	0.07	0.03	0.02						
Smoothee									
	Harvest Picking time			February Picking time			April Picking time		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
ground color (point)	5.6	6.1	6.4	6.0	6.3	6.5	6.3	6.4	6.5
flesh firmness (daN/cm²)	8.9	8.5	7.8	5.4	5.1	4.8	5.1	4.7	4.5
soluble solid content (%)	13.5	14.2	14.3	13.6	14.3	14.4	14.4	14.5	14.5
acid content (%)	0.62	0.55	0.51	0.41	0.38	0.34	0.31	0.28	0.26
starch degradation (point)	2.5	3.0	4.6						
soluble solid / acid cont.	21.7	25.8	28.0	33.2	37.6	42.4	46.5	51.8	55.8
Thieault index	197	197	194	177	181	178	175	173	171
Streif index	0.16	0.11	0.06						
Wellpsur Delicious									
	Harvest Picking time			February Picking time			April Picking time		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
ground color (point)	5.2	6.8	4.3	5.8	6.9	7.4	6.5	7.1	7.4
flesh firmness (daN / cm²)	6.5	5.1	4.8	5.5	4.6	4.5	4.8	4.5	4.4
soluble solid content (%)	13.4	13.5	13.6	13.5	13.6	13.7	13.7	13.7	13.8
acid content (%)	0.52	0.41	0.38	0.46	0.39	0.38	0.45	0.38	0.38
starch degradation (point)	3.2	3.9	4.3						
soluble solid / acid cont.	25.6	32.5	34.9	29.6	35.3	36.5	34.2	35.7	36.8
Thieault index	186	176	174	181	175	175	177	175	176
Streif index	0.07	0.04	0.03						

Table 5 Effect of picking time and storage duration on storage losses (%), average values for various growing sites

	February Picking time			March Picking time			April Picking time		
Jonathan M41	I.	II.	III.	I.	II.	III.	I.	II.	III.
Jonathan spot	4.8	3.6	4.3	5.8	4.7	6.6	6.2	4.8	5.2
scald	0.1	0.3	0.18	0.3	0.4	0.9	0.4	0.5	1.1
bitter pit	0.6	0.2	0.1	1.2	0.4	0.2	1.3	0.6	0.4
breakdown	0.2	0.2	0.4	0.3	0.4	0.5	0.6	0.5	0.9
mass loss	3.9	2.4	3.2	4.9	3.8	4.6	5.6	4.8	5.4
Jonnee									
Jonathan spot	3.6	2.4	5.1	4.2	2.8	5.8	4.8	3.4	6.3
scald	0.15	0.4	1.2	0.4	0.5	1.3	0.6	0.5	1.5
bitter pit	0.4	0.1	0.05	0.7	0.2	0.1	1.3	0.3	0.2
breakdown	0.4	0.3	0.8	0.5	0.4	0.9	0.6	0.5	1.2
mass loss	4.1	3.4	4	6.2	3.9	4.9	7.1	4.8	4.7
Redspur Delicious									
bitter pit	1.6	0.8	0.6	1.9	1.0	2.3	2.3	1.2	2.5
breakdown	0.6	0.8	0.4	0.7	0.9	0.5	0.8	0.9	0.6
mass loss	2.5	3	3.4	3.2	3.6	3.9	3.7	4.1	4.5
Smoothee									
scald	4.5	2.3	3.9	7.4	3.6	4.8	9.8	4.9	5.8
bitter pit	1.1	0.7	0.4	1.4	0.9	0.6	1.6	1.4	1.1
breakdown	0.1	0	0	0.1	0.05	0	0.2	0.1	0.1
mass loss	3.2	2.5	3.6	3.6	2.9	4.1	4.2	3.3	4.5
Wellpsur									
scald	2.1	2.9	3.1	2.8	3.9	4.2	3.2	4.5	5.1
bitter pit	0.89	1.1	0.7	1.16	1.2	1.3	1.3	1.2	1.4
breakdown	0.1	0	0	0.25	0.1	0.2	0.4	0.2	0.3
mass loss	3.1	2.6	2.8	3.9	3.1	3.3	4.3	3.4	3.7
Average values									
Jonathan spot	4.2	2	4.7	5	3.7	6.2	5.5	4.1	5.7
scald	1.71	1.47	2.1	2.71	2.1	2.8	2	2.6	2.42
bitter pit	0.9	0.72	0 .37	1.16	0.74	0.9	1.56	0.94.	1.1
breakdown	0.28	0.26	0.11	0.37	0.34	0.42	0.52	0.44	0.54
mass loss	3.36	2.7	3.4	4.36	3.46	4.16	4.9	4.1	4.6

On base of our experimental data, predictions can be made between various quality parameters of fruits, determined at harvest, as well as storage losses.

The predictor - equations for Jonathan M41, determined by stepwise analysis of regression are as follows :

Mass loss = –2.75 – 0.002mass – 0.460 ground color + 0.313 CC + 0.073 s.s.c. / acid +0.136 flesh firm. + 0.356 s.s.c. – 0.008 starch degr.

$R^2 = 0.52$

Bitter pit = 3.548–0.014 mass + 0.057 ground color –0.0007 CC – 0.0133 s.s.c. / acid –0.001 flesh firm – 0.094 s.s.c.+0.020 starch degr.

$R^2 = 0.84$

Breakdown = 0.526 + 0.007 mass –0.081 ground colouring +0.077 CC +0.002 solu. sol / acid –0.0665 flesh firm–0.003 s.s.c.–0.119 starch degr.

$R^2 = 0.62$

Discussion

The up-to-date Jonathan -type variety, Jonathan M41 has shown a comparatively high soluble solid- acid content ratio after storage. This ratio was rather high at Redspur Delicious and Smoothee. At these varieties the color was very intensive.

According to the analysis of various losses and physiological diseases the high importance of mass loss is obvious. At Jonnee the earlier picking date increased the mass loss considerably. The effect of variety on mass loss is rather limited. At the two Jonathan-type varieties the Jonathan spot was a rather important physiological disease. The late picking time increased the frequency of Jonathan spot. At optimal date of harvest in Jonnee the frequency of Jonathan spot was lower, than in Jonathan M41. In variety Jonathan M41 and Jonnee the importance of scald was rather limited, but in Wellspur Delicious and Smoothee this disease occurred relatively frequently. In Smoothee the earlier picking time considerably increased the probability of scald.

The bitter pit and breakdown was less important. This disease was relative frequent in Redspur Delicious.

The correlation between chemical properties of fruits and the storage losses were tested by simple and multiple regression analysis. The linear correlation coefficient seldom gave reliable results, because the processes investigated were quadratic in most cases. The multiple regression analysis yielded more reliable results, being fit for prediction of storage losses and diseases based on chemical and physical properties, being determined at the time of picking.

References

Aeppli, A. (1984) Qualität Neuer Apfelsorten, Zeitschrift für Obst- und Weinbau 126 (15) 366–371.

Bühnemann O. (1963) Untersuchungen über die CO2 Lagerung der Sorten Jonathan und Golden Delicious , Erwerbsobstbau 5 (1) 5–7.

Lévaváry B. (1972) Some relations between the ripening and storability of Jonathan apple, Fruit and vegetable selling (Budapest, in Hungarian) 7 (9) 30–35.

Lott V.R. (1961) Relation of skin colour of Golden Delicious apples to quality changes during maturation and ripening , Proc. of the Amer. Soc. for Hort. Sci. 65 (1) 61–69.

Sass P. (1993) Fruit storage , Mezõgazda Publishing House, Bp.

Stolle G., Reichel M., Schmidt G. (1985) Der Einfluss von Erntetermin, Fruchtgrösse, Lagerungsverfahren und Lagerungsdauer auf den Geschmack zweier Apfelsorten I:, Arch. Gartenbau, Berlin 132 (4) 139–149.

Tomcsányi P.(1987) Foundations of marketing in food economy, Agtricultural Publishing House (in Hungarian) 425.