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Chemical and organoleptic evaluation of some Finnish apple varieties

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Abstract. Chemical and organoleptic analyses were carried out on ten important locally grown apple varieties. Most of the varieties were characterized by high titratable acidity and fairly low total sugar concentration. Consequently the sugar-to-acid ratio (a suggested indicator of the eating quality of apples) remained low. However, some of the varieties with high acidity (Red Atlas, Raike) were scored high in the preference test, confirming that other factors in addition to the sugar-to-acid ratio have an influence on the palatability of apple juices. Generally it seems that juice from most of the studied varieties should be mixed with low acid, high sugar juices to be suitable for commerical juice production.

The quality of apple products is dependent on several factors, e.g. variety, maturity, and length of storage time of the apples. Each variety has an optimum harvest time as well as storage period to develop the best quality for any intended use. For instance the aroma characteristics and the yield of juice, among other properties, can be influenced greatly by harvest and storage practices.

Several extensive studies have been made on the chemical composition of apples and apple varieties (LOPETZ et al. 1958, KOCHAN 1968, BRADLEY and BROWN 1969, HOLFELDER and EID 1970, MOHR and ADAIR 1970). However, the results of these investigations may not be applicable as such when considering the chemical composition of apples grown in Finland since many of the commercially grown apple varieties are of local origin. Moreover, the unique weather and growing conditions of the country may be reflected in the chemical composition of apples.

Since all varieties are not equally suitable for industrial use (e.g. ROTSTEIN et al. 1969) ten locally important apple varieties (Melba, Charlottenthal, Red Atlas, Antonovka, Raike, Snygg, Erstaa, Kaneli, Lobo, and Åkerö) were screened chemically and organoleptically to find suitable cultivars for apple

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Table 1. Apple varieties, growing locations, dates of harvest, and storage periods.

Variety	Growing location	Date of harvest 1972	Storage period, weeks	Additional information
Snygg	Kangasala	Sept. 5	3	Summer variety
Erstaa	Kangasala	Sept. 5	6	»Berry apple»
Melba	Lohja	Sept. 6	7	Fall variety
Charlottenthal	Lohja	Sept. 6	5	Summer variety
Kaneli	Kirkkonummi	Sept. 11	6	Fall variety
Åkerö	Kirkkonummi	Sept. 11	12	Winter variety
Raike	Piikkiö	Sept. 13	4	Winter variety, novelty
Red Atlas	Lielahti	Sept. 14	12	Winter variety
Lobo	Kirkkonummi	Sept. 24	9	Winter variety
Antonovka	Lohja	Sept. 27	12	Winter variety

juice production. The first five varieties in the list were evaluated chemically in greater detail than the others. Similar local studies have been made on a few other varieties (KUUSI and PAJUNEN 1971).

Materials and methods

Harvest dates and growing locations of the apple varieties studied in this investigation are given in Table 1.

The influence of increased storage time on the following chemical factors was determined:

pH (Official methods of analysis of AOAC 1970)
sugars (SCHOORL and REGENBOGEN 1935)
soluble solids (Official methods of analysis of AOAC 1970)
titratable total acids as malic acid (Official methods of analysis of AOAC 1970)
starch (STOLL 1969, DUBOIS et al. 1956)
phenols (SWAIN and HILLIS 1959)
pectines as Ca pectate (RUCK 1963)
dry matter (72 hours at 70° C under vacuum)
ash (24 hours at 450° C)
mineral elements K, Ca, Mg, and Mn by atomic absorption spectrophotometry (HULME et al. 1958, PERRING 1964, Analytical methods for AAS 1966). Instrument: Perkin-Elmer 303.

The storage conditions were: temperature 5° C, and relative humidity 73—78 %.

The samples for chemical analyses were taken immediately after the apples were received from the orchards, and later at intervals of 2—3 weeks from 2 to 4 times depending on the variety. The apples were washed and rinsed in distilled water, and the endocarps and stalks were removed. For one sample 20 apples were divided into sectors, part of which (300 g) were deep frozen in polyethylene bags until analyzed. For the determination of sugars and phenolic constituents 200 g of apple slices were homogenized and extracted with 80 % ethanol (SALMINEN et al. 1969). Soluble solids, titratable total acids, and pH were determined from the juice pressed in connection with the organoleptic analyses.

The sugar-to-acid ratio of the apples was computed as the ratio of soluble solids and total acids as malic acid.

Juice for the organoleptic analysis was pressed with a Bucher-Guyer juice press. Samples (three parallels) were taken at intervals of 1 to 3 weeks depending on the variety. The size of the samples was 6—8 kg. The apples were rinsed with cold water before crushing. The juice samples were deep frozen in one liter plastic bottles until analyzed.

The organoleptic quality of the apple juices was analyzed by a trained panel of 10 members. In the evaluation of juice quality three methods were used (AMERINE and PANGBORN 1965):

1. The storage time after which the taste of juice differs from that of non-stored apple juice was estimated by the triangle test.
2. The optimum storage time of each variety to develop the best apple flavor and the highest preference was tested with the ranking method.
3. The best juices of the varieties (according to the ranking test) were scored for their sourness, sweetness and preference using the scoring test (hedonic scale).

All tests were repeated.

Results

The gross chemical compositions of the ten apple varieties after different storage periods are given in Table 2. The varieties Melba, Charlottenthal, Raike, Antonovka, and Red Atlas were subjected to a more detailed chemical evaluation. These results are given in Table 3. It is seen that the values of total acids and starch decrease, while pH and the sugar-to-acid ratio increase with the increasing storage time. With sugars the changes are less pronounced, and all other values seem to remain more or less constant.

Juice recovery from the different apple varieties is given in Table 4. The recovery was at its maximum at the time of harvesting and decreased rapidly in the early varieties (Snygg, Charlottenthal, Melba) and more slowly in the late varieties (Åkerö, Antonovka.)

The results of the triangle test are summarized in Table 5. It is seen that the taste of juice from the early varieties changed significantly from the standard (0-storage juice) in 2—3 weeks, while that of the late varieties changed more slowly.

With the ranking test it was found that the apple aroma in the varieties Lobo and Åkerö was significantly weaker at the time of harvesting than in the stored apples. No other significant differences in aroma were found. The preference did not change significantly with an increasing time of storage of the varieties Melba and Erstaa. In the other varieties significant differences were found in preference, and the results are summarized in Table 6. According to the results the optimum storage period for winter varieties was about three weeks, with the exception of Antonovka for which it was 9 weeks. For early varieties the storage period should be no longer than 2 weeks.

Table 2. Gross chemical composition of some Finnish apple varieties.

Variety	Storage time, weeks	Total acids %	pH	Solube solids %	Sugar- to-acid ratio
Melba	0	0.78	3.29	11.5	14.7
	1	0.73	3.36	12.1	16.6
	3	0.65	3.37	12.3	19.1
	5	0.63	3.50	12.3	19.7
	7	0.60	3.43	12.6	21.1
Charlottenthal	0	1.35	3.03	9.8	7.3
	1	1.32	3.05	9.5	7.2
	3	1.33	3.04	9.3	7.0
	5	1.18	3.17	9.3	7.9
Raike	0	1.01	3.19	11.2	11.1
	2	0.88	3.15	11.5	13.1
	4	0.81	3.15	11.2	13.8
Antonovka	0	1.33	2.95	11.8	8.9
	3	1.28	2.97	11.9	9.3
	6	1.20	2.97	11.1	9.2
	9	1.02	3.12	11.4	11.1
	12	0.86	3.14	11.2	13.0
Red Atlas	0	1.19	3.08	12.8	10.8
	3	1.17	3.06	13.1	11.2
	6	1.04	3.19	12.9	12.4
	9	0.87	3.25	12.4	14.2
	12	0.76	3.34	12.3	16.2
Snygg	0	0.75	3.37	10.0	13.1
	1	0.74	3.35	9.3	12.6
	3	0.70	3.29	9.6	13.8
Kaneli	0	0.65	3.32	10.0	15.3
	2	0.63	3.36	10.9	17.5
	4	0.61	3.35	10.4	17.0
	6	0.59	3.54	10.7	18.2
Lobo	0	0.57	3.35	11.4	20.0
	3	0.55	3.42	11.5	20.6
	6	0.50	3.65	11.7	23.3
	9	0.40	3.63	10.3	25.6
Åkerö	0	0.80	3.27	11.1	13.9
	3	0.69	3.35	12.5	18.1
	6	0.66	3.45	12.6	19.2
	9	0.58	3.45	12.3	21.3
	12	0.55	3.50	11.8	21.6
Erstaa	0	1.15	3.27	12.3	10.7
	2	1.10	3.22	12.6	10.2
	4	1.10	3.34	12.3	11.2
	6	1.11	3.34	12.7	11.4

Table 3. Additional chemical analyses on the varieties Melba, Charlottenthal, Raike, Antonovka, and Red Atlas.

	Variety/Storage time in weeks											
	Melba					Charlottenthal				Raike		
	0	1	3	5	7	0	1	3	5	0	2	4
Sugars, total %	7.67	8.09	8.36	8.64	8.65	5.67	5.55	4.60	4.98	7.07	7.71	7.79
reducing %	5.93	6.34	6.28	6.46	6.94	4.65	4.68	4.02	4.50	4.48	4.78	5.06
Starch %	0.46	0.35	0.35	0.29	0.27	0.31	0.20	0.35	0.28	0.46	0.26	0.19
Ca pectate %	0.65	0.59	0.63	0.69	0.69	0.61	0.61	0.66	0.64	0.65	0.62	0.52
Phenols %	0.20	0.25	0.22	0.30	0.31	0.19	0.18	0.18	0.18	0.16	0.13	0.12
Dry matter %	11.7	11.9	11.6	13.0	12.5	9.7	10.2	9.1	9.5	11.3	11.8	11.8
Ash %	0.24	0.24	0.24	0.23	0.26	0.23	0.24	0.25	0.26	0.25	0.27	0.28
Mineral elem. mg%												
K	105	97	106	98	105	97	99	111	108	123	115	112
Ca	4.9	4.6	4.2	4.2	4.1	3.5	4.1	3.8	4.0	4.1	3.8	3.9
Mg	4.8	4.9	4.4	4.5	4.9	5.0	4.8	4.8	5.2	4.0	4.4	4.0
Mn	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.02

	Antonovka					Red Atlas				
	0	3	6	9	12	0	3	6	9	12
Sugars, total %	8.16	7.83	7.06	7.15	7.07	8.86	8.75	8.64	8.41	8.56
reducing %	5.29	5.69	5.98	6.37	6.36	4.98	6.03	6.53	6.03	6.48
Starch %	0.50	0.27	0.25	0.26	0.30	0.59	0.42	0.34	0.34	0.37
Ca pectate %	0.73	0.72	0.61	0.70	0.71	0.69	0.63	0.72	0.68	0.71
Phenols %	0.13	0.16	0.18	0.16	0.17	0.20	0.18	0.19	0.19	0.19
Dry ma ter %	12.5	12.3	11.5	11.5	11.6	13.3	13.2	13.0	12.8	13.1
Ash %	0.27	0.26	0.25	0.25	0.25	0.26	0.26	0.27	0.27	0.26
Mineral elem. mg %										
K	96	99	93	101	103	120	122	115	124	125
Ca	2.7	2.5	3.1	2.9	3.2	3.1	3.5	3.5	4.5	3.7
Mg	4.7	4.7	4.8	5.2	5.0	4.4	4.8	5.2	4.5	4.6
Mn	0.02	0.02	0.01	0.20	0.02	0.02	0.03	0.03	0.02	0.03

Table 4. Juice recovery (%) of some Finnish apple varieties with increasing time of storage.

Variety	Storage period, weeks									
	0	1	2	3	4	5	6	7	9	12
Melba	76.0	64.3	—	65.8	—	61.8	—	52.6	—	—
Charlottenthal	75.5	75.2	—	68.2	—	59.0	—	—	—	—
Snygg	64.7	56.1	—	49.9	—	—	—	—	—	—
Erstaa	73.2	—	73.7	—	66.1	—	65.6	—	—	—
Kaneli	76.5	—	71.5	—	69.1	—	56.5	—	—	—
Raike[1]	76.1	—	79.5	—	79.4	—	—	—	—	—
Lobo	74.0	—	—	72.6	—	—	56.0	—	46.5	—
Åkerö	74.0	—	—	73.1	—	—	71.2	—	66.3	55.8
Red Atlas	74.3	—	—	66.0	—	—	53.1	—	51.1	—
Antonovka	76.2	—	—	74.4	—	—	61.0	—	58.6	50.4

[1]) Juice pressed with a Braun juice centrifuge

Table 5. Appearance of significant changes in taste with increasing storage time.

Variety	Storage time weeks	Significance of change in taste[1])
Kaneli	2	***
Melba, Erstaa	2	*
Melba, Åkerö, Lobo, Snygg	3	***
Charlottenthal, Antonovka	3	*
Charlottenthal	5	***
Antonovka	6	***
Red Atlas	6	**
Red Atlas	9	***

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

[1]) Compared to juice from O-storage apples

Table 6. Significant differences in the preference of juices within each variety

Variety	Storage time weeks	Preference	
		liked	not liked
Snygg	3	—	*
Charlottenthal	5	—	**
Kaneli	4	**	—
Åkerö	0	—	**
Åkerö	3	**	—
Antonovka	3	—	**
Antonovka	9	**	—
Lobo	3	**	—
Red Atlas	3	*	—

* $P < 0.05$
** $P < 0.01$

The different varieties were also scored with each other. A commercial product was used as standard. The scores were brought on the same scale by equalizing the scores of the standard. The stronger the quality tested the higher the score (maximum score for sourness was 4, for sweetness and preference 5). The results (Table 7) show that apples of low sourness and high sweetness are considered best (Raike, Åkerö, Lobo, Kaneli). The commercial products were not liked. This may be due to the changes in apple aroma caused by sterilization.

Discussion

The best chemical estimates for the quality of taste are the total sugar content and the sugar-to-acid ratio (DAEPP 1970). The titratable acid contents of the studied varieties are high compared to some reported values (e.g. VESTRHEIM 1971). As a consequence the sugar-to-acid ratios remain fairly low

Table 7. Sourness, sweetness and preference scores of juices from different apple varieties[1])

Variety	Sourness[2])		Sweetness[3])		Preference[4])	
	mean	range	mean	range	mean	range
Melba	1.7	1—3	2.5	2—3	2.9	2—4
Charlottenthal	4.1	3.5—4.5	1.6	1—2	1.9	1—3
Snygg	1.8	1—3	2.5	1—3	2.8	1—4
Erstaa	3.2	2—4	1.8	1—3	1.8	1—3
Kaneli	1.2	1—2	3.3	3—5	3.3	2—5
Red Atlas	2.3	1—3	3.2	2—4	3.1	2—4
Lobo	1.0	1	4.4	3—5	3.7	2—5
Åkerö	1.5	1—3	3.7	2—5	3.7	1—5
Antonovka	3.2	1.5—4.5	2.3	1—3	2.9	1—4
Raike	2.1	1.5—3.5	3.4	3—4	3.8	2—5
Commercial juice A[5])	2.9	2—4	2.5	1—4	2.2	1—4
Commercial juice B	2.5	1.5—3.5	2.9	2—4	1.9	1—3

[1]) Juices ranked highest in the ranking test
[2]) 1 = weakly sour, 4 = very sour
[3]) 1 = weakly sweet, 5 = very sweet
[4]) 1 = not liked, 5 = liked very much
[5]) Standard

although they reach acceptable values (10—25) during storage in most cases. Also the sugar content of the Finnish apple varieties is comparatively low.

The correlations between the organoleptic and some chemical characteristics are given in Table 8. It shows that there is a high correlation between sugar-to-acid ratio and preference, while soluble solids (a measure of sugar content) and preference show no correlation. On the other hand, total acids and preference show a fairly high negative correlation. There were exceptions from the general line in the case of Raike and Red Atlas. Juice from these apples was scored high in the preference test even though the acidity was high (Raike 0.88 % and Red Atlas 1.07 %) and the sugar-to-acid ratio low (Raike 13.0 and Red Atlas 11.4). The juice from these varieties has a strong, pleasant apple aroma, which may well account for their preference. This shows that the sugar-to-acid ratio alone is not a reliable measure of the organoleptic quality.

The processing qualities and the juice yield of Antonovka in particular, but also of Åkerö and Red Atlas, are suitable for industrial juice production. However, these varieties show a fairly high acidity (Antonovka also feeble

Table 8. Correlations between organoleptic and some chemical analyses.

Chemical analysis		Organoleptic analysis	Correlation
Total acids %	x	sourness	0.93
Soluble solids %	x	sweetness	0.34
Sugar-to-acid ratio	x	preference	0.70
Total acids %	x	preference	—0.43
Soluble solids %	x	preference	—0.01

aroma qualities), and alone they will not yield palatable juices. Of the studied varieties only Lobo has, in addition to reasonable processing qualities, a high enough sugar content and a low enough acidity to be suitable for mixing as a taste softener with high acidity juices.

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SELOSTUS

Eräiden suomalaisten omenalajikkeiden kemiallinen ja aistinvarainen laatututkimus

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Kymmenen kotimaista omenalajiketta (Melba, Charlottenthal, pun. Atlas, Antonovka, Raike, Snygg, Erstaa, Kaneli, Lobo ja Åkerö) analysoitiin kemiallisesti ja aistinvaraisesti tarkoituksena löytää sopivia lajikkeita teolliseen tuoremehun valmistukseen. Tutkituille lajikkeille tunnusomaista oli yleensä korkea titrattava happoisuus sekä suhteellisen alhainen sokeripitoisuus. Tästä syystä myös sokeri-happosuhde, jota on pidetty parhaana omenan makuominaisuuksia kuvaavana kemiallisena kriteerinä, jäi alhaiseksi. Toisaalta aistinvaraisessa tutkimuksessa arvostettiin varsin korkealle joitakin sellaisia lajikkeita (pun. Atlas, Raike; kummallakin voimakas hedelmäinen aromi), joiden sokeri-happosuhde oli alhainen. Tämä vahvistaa käsitystä, ettei ko. suhde yksinään anna riittävän luotettavaa kuvaa omenan makuominaisuuksista.

Prosessointiominaisuuksiensa ja mehusaaliinsa puolesta erityisesti Antonovka, mutta myös Åkerö ja pun. Atlas soveltuisivat hyvin teolliseen tuoremehun valmistukseen. Nämä lajikkeet ovat suhteellisen happamia (Antonovka myös heikkoarominen), ja siten yksinään käytettyinä liian voimakkaan makuisia maittavan mehun raaka-aineeksi. Tutkituista lajikkeista ainoastaan Lobo, joka prosessointiominaisuuksiltaan on tyydyttävä, on riittävän sokeripitoinen ja vähähappoinen soveltuakseen käytettäväksi seoksena happamien mehujen kanssa maun pehmentäjänä.