

Quality attributes of stored apples

Kvalitetssegenskaber hos lagrede æbler

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Summary

During a 2 year period the cultivars 'Boskoop', 'Elstar', 'Gloster', 'Mutsu' and 'Spartan', were stored in cold storage at 3°C and CA-storage with 0% oxygen and 3% carbon dioxide.

Firmness, soluble solids, sugars, and titratable acid were measured immediately after harvest and storage. Determination of dietary fibre and minerals was carried out only immediately after harvest.

As expected, the cultivars differed in content of all the measured attributes, but the variation between years was almost as great as the variation

between cultivars.

By use of the measured quality attributes it was possible to divide the cultivars into groups which differed for each of the quality characteristics.

The firmness and content of vitamin C and titratable acid decreases considerably during storage.

Because of increasing content of soluble solids and decreasing content of titratable acid the sweetness of the apples increases during storage.

During storage the content of sucrose decreases and the content of glucose and fructose increases.

Key words: Apples, storage, dietary fibres, minerals, vitamin C, sugars, firmness.

Resume

I 2 år blev sorterne 'Boskoop', 'Elstar', 'Gloster', 'Mutsu' og 'Spartan' lagret på køl ved 3°C og på CA-lager ved 0% ilt og 3% kuldioxyd. Fasthed, opløseligt tørstof, sukkerarter og titrerbar syre blev bestemt efter høst og efter lagring.

Som det kunne ventes, var der betydelige sortsforskelle. Det var muligt at inddele sorterne i forskellige

grupper for hver kvalitetsegenskab.

Indholdet af kostfibre og mineraler blev kun bestemt efter høst. Fasthed og indhold af vitamin C aftog betydeligt under lagringen. Under lagring forøges indholdet af sukker, og indholdet af titrerbar syre aftager. Dette betyder, at æblerne bliver mere søde.

Nøgleord: Æbler, lagring, kostfibre, mineraler, vitamin C, sukkerarter, fasthed.

Introduction

In order to extend the marketing period it is necessary to store a considerable amount of apples. The maximum storage time for early cultivars such as 'Discovery' and 'Summerred' in cold storage are 4-6 weeks. 'Cox Orange', 'Ingrid Marie', 'Elstar', 'Mutsu', 'Spartan' and 'Jonagold' can be stored for about 3 months in cold storage, but 4-6 months in controlled atmosphere (CA-storage).

The aim of this paper is to describe the content of nutrients and other quality attributes of some major apple cultivars grown under Danish conditions and stored in cold storage and controlled atmosphere.

Materials and methods

In 1989 and 1990 a storage experiment with 'Boskoop', 'Elstar', 'Gloster', 'Mutsu' and 'Spartan' was carried out. Table 1 shows the applied sizes of apples and the storage time.

Under CA-storage the content of oxygen (O₂) and carbon dioxide (CO₂) was 0 and 3% respectively. The temperature in CA-storage was 3°C for 'Boskoop', 'Elstar' and 'Spartan', while 'Gloster' and 'Mutsu' were kept at 1°C.

The apples were analyzed immediately after harvest, after cold storage and after CA-storage.

Analyses for soluble solids, titratable acid, firmness and vitamin C were carried out as described earlier (6). The content of dry matter was measured by drying overnight at 80°C. Minerals were measured by use of atomic absorption spectrometry.

High pressure chromatography was used for determination of sugars. 500 g apple were homogenized with 250 g water in a Waring blender for 5 minutes. The homogenate was centrifuged at 4°C for 20 minutes at 1000 × g after which it was fil-

tered through a filter paper into small vials. The analysis were carried out as reversed phase chromatography using a Supelcosil LC-NH₂ 25 × 4.6 mm column, 5 µm packing at 35°C and a flow rate of 2 ml/min with a mobile phase of acetonitrile: water (75:25) and refractive index detection. The extracts were diluted 50 times before injection. Injection volume was 50 µl. The fructose, glucose and sucrose were identified by use of retention time.

Dietary fibre was measured by use of the method described by Asp et al. (1).

Results

Table 2 shows the content of dietary fibres and minerals. The cultivars 'Elstar' and 'Gloster' had a low content of fibre, and 'Boskoop' had the highest content. Results from analyses for minerals show that 'Boskoop' and 'Spartan' had the lowest (72 mg/kg) and highest (88 mg/kg) content of calcium (Ca). The other cultivars contained about 80 mg/kg.

With respect to potassium and magnesium the cultivars can be divided into 2 groups for each mineral. 'Boskoop', 'Elstar' and 'Gloster' contained 1450 -

Table 1. Size of apples (diameter) and storage time. *Æblestørrelse (diameter) og lagringstid.*

Cultivar Sort	Size Størrelse mm	Cold storage Kølelagring Months Måneder	CA-storage CA-lagring
'Boskoop'	70 - 80	2	4
'Elstar'	60 - 70	2	4
'Gloster'	70 - 80	2	5
'Mutsu'	70 - 80	2	5
'Spartan'	60 - 70	2	4

Table 2. Average content of dietary fibre and minerals. (Cultivars: average of year; year: average of cultivars). *Gennemsnitligt indhold af kostfibre og mineraler. (Sorter: gennemsnit for år; år: gennemsnit for sorter).*

Cultivar Sorter	Fibre Fibre %	Ca	K	Mg	Zn
mg/kg					
'Boskoop'	3.3	72	1454	57	0.7
'Elstar'	2.2	78	1500	58	0.6
'Gloster'	2.2	82	1442	51	0.4
'Mutsu'	2.9	78	1029	51	0.5
'Spartan'	2.7	88	1069	49	0.6
LSD	0.3	7	356	6	0.2
Year År					
1989	2.7	76	1107	56	0.5
1990	2.5	89	1559	47	0.5
LSD	0.3	6	200	3	0.1
Average Gennemsnit					
Average	2.7	81	1287	52	0.5

Table 3. Average firmness (kg) and content of total dry matter (%), titratable acid (g/kg) and vitamin C (mg/100g). (Cultivars: average of year and time; year: average of cultivars and time; time: average of cultivars and year).

Gennemsnitligt indhold af tørstof, titrerbar syre, vitamin C samt fasthed (Sorter: gennemsnit for år og tidspunkt; år: gennemsnit for sorter og tidspunkt; tidspunkt: gennemsnit for år og sorter).

Cultivar Sort	Total dry matter Totaltørstof %	Titratable acid Titrerbar syre g/kg	Vitamin C Vitamin C mg/100g	Firmness Fasthed kg
'Boskoop'	15.8	10.5	12	7.1
'Elstar'	16.2	7.3	7	5.4
'Gloster'	14.9	6.2	5	8.0
'Mutsu'	16.1	5.6	13	7.8
'Spartan'	14.9	4.5	3	7.0
LSD	0.6	0.4	1	0.6
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Year År				
1989	16.0	7.4	9	7.2
1990	14.9	5.9	5	7.2
LSD	0.3	0.2	1	0.4
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Time (after) Tidspunkt (efter)				
Picking	15.8	7.0	9	9.0
Plukning				
Cold storage	15.3	6.8	6	6.2
Kølelagring				
CA-storage	15.0	6.1	5	5.8
CA-lagring				
LSD	0.4	0.3	1	0.5
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Average Gennemsnit	15.5	6.7	8	7.2

1500 mg/kg of potassium and 'Mutsu', and 'Spartan' had a content of about 1000 mg/kg. 'Gloster', 'Mutsu' and 'Spartan' contained about 50 mg/kg of magnesium and 'Boskoop' and 'Elstar' had a significantly higher content of about 60 mg/kg.

With the exception of zinc, the content of minerals was different each year. The content of magnesium was lowest in 1990 and the content of calcium and potassium was lowest in 1989.

The results from determination of total dry mat-

Table 4. Average content of soluble solids, sucrose, glucose and fructose (Cultivars: average of years and time; year: average of cultivars and time; time: average of cultivars and year).

Gennemsnitligt indhold af opløseligt tørstof, sukrose, glukose og fruktose (Sorter: gennemsnit for år og tidspunkt; år: gennemsnit for sorter og tidspunkt; tidspunkt: gennemsnit for sorter og år).

Cultivar Sort	Soluble solids Opløseligt tørstof g/100 g	Sucrose Sukrose g/100 g	Glucose Glukose g/100 g	Fructose Fruktose g/100 g
'Boskoop'	12.6	3.9	1.4	5.3
'Elstar'	13.3	4.0	1.3	6.5
'Gloster'	11.7	2.4	2.4	5.5
'Mutsu'	12.9	3.6	1.3	6.6
'Spartan'	11.6	2.4	1.3	7.1
LSD	0.4	0.3	0.2	0.3
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Year År				
1989	13.0	3.9	1.4	6.2
1990	11.5	2.3	1.9	6.0
LSD	0.4	0.2	0.1	0.2
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Time (after) Tidspunkt (efter)				
Picking	11.8	3.7	1.2	5.8
Plukning				
Cold storage	12.9	3.3	1.6	6.1
Kølelagring				
CA-storage	12.3	2.0	2.3	6.7
CA-lagring				
LSD	0.4	0.2	0.1	0.2
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Average Gennemsnit	12.3	3.1	1.7	6.2

ter, titratable acid, vitamin C and firmness are shown in table 3. Compared with the other cultivars 'Gloster' and 'Spartan' had a low content of dry matter. The content of titratable acid and vitamin C was different in all cultivars. The content of titratable acid was highest in 'Boskoop' and lowest in 'Spartan'. The lowest content of vitamin C was found in 'Gloster' and 'Spartan' and the highest content was found in 'Boskoop' and 'Mutsu'.

With respect to texture the cultivars could be di-

vided into 3 groups with decreasing firmness: 1) 'Gloster' and 'Mutsu'; 2) 'Boskoop' and 'Spartan'; 3) 'Elstar'.

The content of dry matter, titratable acid and vitamin C were higher in 1989, but the average firmness was the same each year.

The firmness and the content of dry matter, titratable acid and vitamin C decreased during storage.

Table 4 shows that the content of soluble solids was highest in 'Elstar' followed by 'Boskoop' and 'Mutsu' and a significant lower content in 'Gloster' and 'Spartan'.

Except for glucose the content of sugars and soluble solids was highest in 1989.

During storage the concentration of sugars changed significantly. The content of sucrose decreased and the contents of fructose and glucose increased.

Discussion

The content of soluble solids, titratable acid, sugars, vitamin C and minerals is in accordance with values published, from which it appears that the content in cultivars are different and that the growing conditions is of importance (2, 3, 4, 5, 7, 8, 10, 11). As expected, the cultivars differed in content of all the measured attributes, but the variation between years was almost as great as the variation between cultivars. By use of the measured quality attributes it was possible to divide the cultivars into groups for each of the quality characteristics.

Immediately after harvest the concentrations of fructose and glucose are equal, but this changes during the storage period. The content of sucrose decreases and the content of fructose and glucose increases (5).

During storage vitamin C may disappear almost completely and it has been found that the change is highest in CA-storage (3, 5, 12).

Because of decreasing content of titratable acid and increasing content of sugars the sweetness of the apples increases during storage. The firmness decreases during storage as shown earlier (6,9).

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