Dynamic controlled atmosphere for storage of organic apples

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Organic apples can be stored for a period of five month with a high quality after storage at dynamic controlled atmosphere, but the subsequent shelf life quality is rapidly reduced although better than at ambient air storage.

The yield in organic apples in Denmark is less than one-third of the conventional production, which is round 40 tons/ha. Furthermore there is a significant loss during storage. The low yield and the high loss during storage is a waste of resources. Therefore, alternative methods to increase yield and maintain quality during storage are extremely important to develop and evaluate.

During storage respiration from the apples will decrease the quality of the apples. Therefore the apples are kept at low temperature (+1°C depending on cultivar) to minimize respiration and oxygen content at the storage room can be lowered to reduce respiration from the apples as much as possible without creating anaerobic conditions.

New technique: Dynamic controlled atmosphere

A new storage technique, dynamic controlled atmosphere (DCA)1 is based on an online monitoring of the responses from the stored apples to the lowering of oxygen during storage. By measuring the chlorophyll fluorescence from the apples, the critical oxygen content can be assessed online and without opening the storage room. Below the anaerobic compensation point, which is specific for each variety the fluorescence from the apples will increase. This information can be used to adjust the oxygen content dynamically during the storage just above the anaerobic compensation point.

During the first weeks of storage the responses from the apples are monitored for anaerobic conditions using fluorescence from the apples as control. When no change in fluorescence is observed, the oxygen content is slowly lowered to the so-called anaerobic compensation point. When the first sign of anaerobic conditions is observed by a change in chlorophyll fluorescence, the oxygen content in the storage atmosphere is raised to a level just about the anaerobic conditions. The critical oxygen level is not a fixed value, but varies between 0.3 to 0.6% oxygen, depending on variety, ripeness and year.

The technique has shown promising results in research in organic apples in Germany where researchers at Fruit Research Station Jork, have been working with the method for some years. The results have shown that quality as firmness is better and storage rot less compared to traditional controlled atmosphere at steady low oxygen, controlled atmosphere (CA) of apples. Moreover physiological disorders like scald, skin spots or internal browning are reduced.

Organic Elstar

In the present project the apple variety Elstar grown organically was harvested in October and stored from November to April under DCA (from 2% O_2 to 0.45% O_2, 2% CO_2 and rest as N_2), or under CA at a steady oxygen content (2%) and compared to storage under ambient oxygen (20%). The temperature in all treatments was +1 °C (±0.3). The oxygen level in DCA was lowered slowly from 2% O_2 to the anaerobic compensation point monitored by chlorophyll fluorescence and then raised just above the point to 0.45% O_2. The chlorophyll fluorescence was monitored on-line and measurements taken every 15 minutes.

During the storage period samples of apples were taken four times for measurements of ethylene (incubation in glass for 4 hours) and quality control (firmness, acid, sugar) before and after shelf life of 14-days (16°C, 97 % RH). Shelf life quality determined as firmness and absence of fungi blotch is a very important parameter, as the consumers will expect high quality from organic apples bought at a higher price than conventional.

Ethylene development

The dynamic atmosphere reduced the respiration from the apples compared to

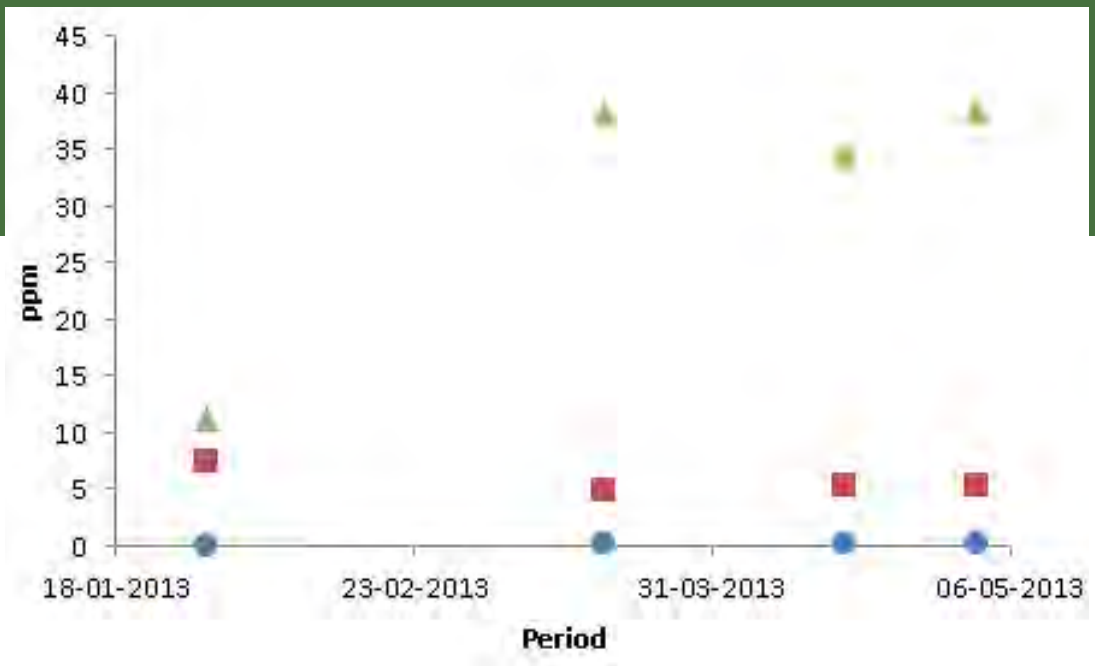

Figure 1 Ethylene development (ppm) from apples, Elstar, stored at DCA (●), CA (◎) and ambient oxygen (◎) in relation to storage time and conditions. (Ethylene determined from samples of apples after four hours at 16°C at ambient oxygen). There are significant differences between the treatments at all sampling dates.

CA and control. The ethylene measurements showed that the DCA method could reduce ethylene from the apples to very low levels compared to CA and control, Fig. 1. An even low level of ethylene will increase the ripening of the apples during storage decreasing the quality of the apples especially the firmness of the apples.

Firmness and shelf life

Firmness after storage was significantly higher at DCA and CA compared to control at the first sampling in late January (Table 1). A firmness higher than 5 kg/cm2 is required from retailers as quality parameter in Elstar apples. However, after shelf life the firmness decreased more rapidly in DCA compared to CA. In March the firmness was still high at DCA after storage, but decreased after shelf life and was not significant to control and CA. The firmness decreased further in April and May revealing that long time storage of the apples is not possible without losing quality. The storage rot was very low in all treatments even after shelf life.

In May physiological disorders were observed in DCA. Probably the apples were more sensitive to low temperature at the storage later on, when kept at very low oxygen.

The firmness of the apples in all treatments was lowered significant after shelf life period of 14 days revealing that the physiological conditions of the apples are changing very rapidly even after optimal storage conditions. The results show that it is possible to store apples under very low oxygen with good results concerning firmness for a rather long period until late March, but shelf life is reduced.

The physiological and biochemical responses during shelf life period should be given much more attention in future research in relation to preharvest effect during production and storage.

Table 1. Firmness (kg/cm²) of apples, Elstar, after storage at DCA, CA and ambient oxygen and after 14-days of shelf life at 16°C and 97% RH. Different letters within each date and storage time indicate significant difference between treatments.

	DCA (0.45% O_2)		CA (2% O_2)		Ambient oxygen (20%)	
	After storage	After shelf life	After storage	After shelf life	After storage	After shelf life
Storage - shelf life	kg/cm²					
29/1-12/2	5.638a	4.972b	5.575a	5.418a	4.83b	4.572c
18/3-3/4	5.589a	3.894ns	5.207b	3.817ns	4.46c	3.761ns
16/4-30/4	5.088a	3.643b	5.089a	3.957a	4.403b	3.675b

More information

Read more about the Organic RDD project FruitGrowth at: http://www.icrofs.org/Pages/Research/organicrdd_fruitgrowth.html

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