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Newly developed MA-box tested with British broccoli

Influence of stalk end treatments

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Confidential

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In close cooperation with KAPPA PACKAGING
and Univeg

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Summary

A modified atmosphere box (MA-box) for broccoli has been developed by ATO-DLO in close cooperation with KAPPA PACKAGING (QUAMA project). The first pilot test with the newly developed MA-box from Sacoje (La Hoya, Spain) to Univeg (Boston,UK) proved its high potential in practice. Especially the most important quality aspect, the retention of the green colour of the broccoli in the MA-box was proven compared to the broccoli in the currently used box. In addition a great reduction of weight loss was demonstrated and no effect could be found on the taste of the broccoli. However the brownish/blackish discolouration of the stalk ends of the broccoli proved to be more pronounced in the MA-box. This was judged unacceptable for use in the supermarkets in England e.g. Sainsbury's.

Further extensive research on a laboratory scale with broccoli from more than 40 Dutch and British growers showed that humid conditions, as appearing in MA-boxes, enhance the intensity of the stalk end discolouration. Stalk end discolouration of an unacceptable level though, was hardly observed during most of the tests. This proved that discolouration of the stalk end is related with certain yet undefined intrinsic properties of the product.

Extensive research aimed at obtaining proper stalk ends proved that in MA packages as well as in non MA packages, discolouration of the stalk end during storage and distribution can be minimized by recutting the stalk ends with a sharp and disinfected knife before packing.

Aims of test

In this report a second pilot test with broccoli from Univeg (Boston,UK) is described. The objectives of this trial were:

- to prove that the MA-box also has a positive effect on the quality of English broccoli;
- to prove that discolouration of the stalk ends can be minimized on a practical scale by recutting the broccoli in the right way.

Description of test

The trial was carried out at ATO-DLO (Wageningen, The Netherlands) with broccoli from 3 Univeg growers. After harvest the broccoli was successively precooled, packed in polystyrene boxes with ice and transported by a refrigerated truck from Univeg in Boston to ATO-DLO in Wageningen.

Immediately after arrival at ATO-DLO the broccoli was packed in either MA-boxes or in open EPS crates (Euro Pool System). Before packing the stalk ends were recut in 4 different ways. After packing the MA-boxes and the crates with broccoli were stacked on separate pallets. The broccoli was stored for 2 days at 12 °C, 1 day at 15 °C, 3 days at 12 °C and 2 days at 10 °C with a $\pm 90\%$ relative humidity. After storage the quality of the broccoli was judged by product experts.

After precooling at Univeg a small sample of MA-boxes and crates were already packed with broccoli in order to simulate the working method of Univeg on a limited scale. During storage at ATO-DLO those boxes were not stacked on pallets but on separate stacks.

Conclusions

- *The MA-box retains the quality of English broccoli better compared to the currently used crate*
- *The MA-box strongly inhibits the yellowing of the broccoli heads.*
- *The stalk end discolouration can be minimised for broccoli packed in both MA-boxes and crates by recutting the broccoli with a sharp and disinfected knife before packing.*
- *The stalk end discolouration of broccoli packed in MA-boxes is stimulated compared to broccoli in EPS-crates. Recutting the stalk ends with sharp and disinfected knives before packing avoids the effect.*
- *The MA-box strongly reduces the weight losses of the broccoli compared to the crates.*

- *The possible effect of the MA conditions on the quality of the broccoli in the MA-box strongly overrules possible negative effects of a higher temperature.*

1. Introduction and objectives

Modified Atmosphere Packaging (MAP) of fruits and vegetables is widely used as an inexpensive method to preserve quality during distribution. At the moment a wide variety of MA-consumer packages is used in practice. ATO-DLO and KAPPA PACKAGING developed in close cooperation a technique to use the MA principles in recycleble transport packages (QUAMA project). A nice example of the possibilities of this new packaging technique is the newly developed MA-box for broccoli.

The first pilot test with the newly developed MA-box from Sacoje (La Hoya, Spain) to Univeg (Boston, UK) proved its high potential in practice. Especially the most important quality aspect, the retention of the green colour of the broccoli in the MA-box was proven compared to the broccoli in the currently used box. In addition a great reduction of weight loss was demonstrated and no effect could be found on the taste of the broccoli. However the brownish/blackish discolouration of the stalk ends of the broccoli proved to be more pronounced in the MA-box. This was judged unacceptable for use in the supermarkets in England e.g. Sainsbury's.

Further extensive research on a laboratory scale with broccoli from more than 40 Dutch and British growers showed that humid conditions, as appearing in MA-boxes, enhance the intensity of the stalk end discolouration. Stalk end discolouration of an unacceptable level though, was hardly observed during most of the tests. This proved that discolouration of the stalk end is related with certain intrinsic properties of the product. As far as we know, the exact mechanisms behind these intrinsic properties are rather unknown.

Extensive research at ATO-DLO aimed at obtaining proper stalk ends treatment proved that in MA packages as well as in non MA packages, discolouration of the stalk ends during storage and distribution can be minimized by recutting the stalk end with a sharp and disinfected knife before packing.

In this report a second pilot test with broccoli from Univeg is described. The objectives of this trial were:

- to prove that the MA-box also retains the quality of English broccoli;
- to prove that discolouration of the stalk ends can be minimized on a practical scale by recutting the broccoli in the right way.

2. Materials and methods

2.1. Short description of the trial

Broccoli packed at ATO-DLO

The trial was carried out at ATO-DLO with broccoli from 3 Univeg growers. After harvest the broccoli was successively precooled, packed in polystyrene boxes with ice and transported by a refrigerated truck from Univeg in Boston to ATO-DLO in Wageningen.

Immediately after arrival at ATO-DLO the broccoli was packed in either MA-boxes or in open EPS crates (Euro Pool System). Before packing the stalk ends were recut in 4 different ways. After packing the MA-boxes and the crates with broccoli were stacked on separate pallets. The broccoli was stored for 2 days at 12 °C, 1 day at 15 °C, 3 days at 12 °C and 2 days at 10 °C with a $\pm 90\%$ relative humidity. After storage the quality of the broccoli was judged by product experts.

Broccoli packed at Univeg

After precooling a small sample of MA-boxes and plastic crates (used by Univeg for the English market) were already packed with broccoli at Univeg in order to simulate the working method of Univeg on a limited scale. During storage at ATO-DLO those boxes were not stacked on pallets but on separate stacks.

2.2. Product, treatments, packing and storage

Repetitions

Each treatment was repeated 4 times (4 boxes/crates per grower per type of stalk end treatment).

Stalk end treatment

Before packing the broccoli at ATO-DLO the stalk ends were recut in 4 different ways namely:

- no recutting;
- recutting with a sharp disinfected knife (highly diluted chloride solution);
- recutting with a sharp infected knife (infected with decaying broccoli);
- recutting with a blunt disinfected knife (highly diluted chloride solution).

The broccoli packed at Univeg in 8 MA-boxes and 8 crates was recut in 2 different ways namely:

- no recutting;
- recutting with a sharp and disinfected knife (highly diluted chloride solution).

Product and packing

The trial was divided into 2 different parts:

- packing of the broccoli in MA-boxes and crates at Univeg before transportation from Univeg to ATO-DLO (only 8 MA-boxes and 8 crates);
- packing of the broccoli in MA-boxes and crates at ATO-DLO after transportation from Univeg to ATO-DLO (48 MA-boxes and 48 EPS-crates).

Broccoli from 3 growers was harvested early in the morning of August 11th. Immediately after harvest the fieldheat was removed by cooling the broccoli down to 5 °C within a few hours.

In the afternoon 8 MA-boxes (8 kg broccoli per box) and 8 crates (6 kg per crate) were packed with broccoli from one of the 3 growers and then put back in the cold store. Before packing the stalk ends were given a stalk end treatment (see *Stalk end treatment*).

August 12th the remaining broccoli was loosely packed in polystyrene boxes with topped ice and polystyrene lids. Ice was also added on top of the 8 already packed crates. After that the broccoli was transported by a refrigerated truck at 5 °C to ATO-DLO.

The broccoli arrived in the morning of August 13th. The broccoli packed in the polystyrene boxes was given a stalk end treatment and was subsequently packed in MA-boxes (8 kg per box) and EPS crates (6 kg per crate).

The boxes and crates packed at ATO-DLO were stacked on separate pallets and put in the cold store at 12 °C. The boxes and crates packed at Univeg were stacked on separate stacks in the same cold room.

Storage

The broccoli was successively stored for 2 days at 12 °C, 1 day at 15 °C, 3 days at 12 °C and 2 days at 10 °C with a $\pm 90\%$ relative humidity. The range of temperatures was chosen during storage in order to be sure to see clear differences between the broccoli packed in MA-boxes and broccoli packed in crates after storage for ± 1 week. Immediately after storage the quality of the broccoli was judged (Friday August 21th).

2.3. Measurements

Temperature

The temperature of the broccoli and the surrounding air inside the boxes and crates was monitored using Escort loggers.

Concentrations O₂ and CO₂

The concentrations O₂ and CO₂ inside 18 MA-boxes that had been chosen at random were measured after 5 days storage at ATO-DLO. The measurements were carried out with a Chrompack gasanalyser (type 2002). Data on internal gas concentrations can explain the MA-effects.

External quality of the broccoli

The external quality of the broccoli was measured directly after storage at ATO-DLO.

- Colour of the broccoli heads was judged according to a scale ranging from 7 (mature green) to 0 (completely yellow). When the first buds start opening the colour of the head is valued 6.
- The stalk end discolouration was judged according to a scale ranging from 0 (no discolouration) to 5 (completely brownish black).
- Decay and mould were measured according to a scale ranging from 0 (no decay/mould) to 5 (severe decay/mould).
- The weightloss of the broccoli was measured of all boxes and crates packed at Univeg and of 4 MA-boxes and 4 crates packed at ATO-DLO.

3. Results

As the results showed only slight differences in level between the 3 separate growers all the data of the 3 growers are averaged. For the same reason the data of the 2 separate parts of the trial (1 packed at Univeg, 1 packed at ATO-DLO) are averaged for the 2 quality aspects 'colour of the broccoli heads' and 'the stalk end discolouration' .

Colour of the broccoli heads

Table 1 shows the average colour of the broccoli heads after storage. Photographs 1 and 2 clearly illustrate these results.

Table 1. Average colour of the broccoli heads after storage on Friday August 21th (7=green, 0=yellow).

Colour of broccoli heads (7-0)	
MA-box	5.5
EPS-crate	3.2

The results show that the MA-box strongly inhibited the yellowing of the broccoli heads.

Stalk end discolouration

Table 2 shows the average discolouration of the stalk ends after storage. Photograph 2 shows the effect of recutting with a sharp and disinfected knife compared to no recutting after harvest.

Table 2. Average stalk end discolouration after storage on Friday August 21th (0=no discolouration, 5=completely brownish/blackish).

	MA-box	EPS-crate
No recutting after harvest	3.5	2.5
Recut with sharp disinfected knife	0.5	0.5
Recut with sharp infected knife	4.2	2.5
Recut with blunt disinfected knife	4.1	1.5

Photograph 1. Quality of broccoli packed in MA-boxes and in EPS-crates after storage on Friday August 21th. Before packing the stalk ends had been recut with a sharp disinfected knife (left MA-boxes, right EPS-crates).

Photograph 2. Effect on the stalk end discolouration of recutting with a sharp and disinfected knife compared to no recutting after harvest (left MA-box, right EPS-crate).

The results show that the stalk end discolouration of broccoli can be minimised for both MA-boxes and EPS-crates by recutting the broccoli with a sharp and disinfected knife before packing. The results also show that the stalk end discolouration of broccoli packed in MA-boxes is stimulated compared to broccoli in EPS-crates. However when the stalk ends had been recut with sharp disinfected knives, no differences were found between broccoli packed in MA-boxes and in crates.

Decay and/or mould

No decay and/or mould were observed.

Weight loss

Table 3 shows the averages weight losses of the broccoli after storage.

Table 3. Average % weight loss of the broccoli after storage on Friday August 21th.

	Route	Average % weight loss
MA-boxes packed at Univeg	UK-NL	2.1
MA-boxes packed at ATO-DLO	NL	1.7
Crates packed at Univeg	UK-NL	8.0
EPS-crates packed at ATO-DLO	NL	7.8

The table shows that the MA-boxes strongly reduced the weight losses of the broccoli compared to the crates. The broccoli packed in crates was very much dehydrated (data not shown).

Temperature during storage

Figure 1 shows the temperature of the broccoli inside the MA-boxes and crates packed at ATO-DLO. The measurements started during packing at ATO-DLO (August 13th) and ended after storage (August 21th). The data of the broccoli packed at Univeg are not shown.

Figure 1. Temperature of the broccoli packed at ATO-DLO during storage

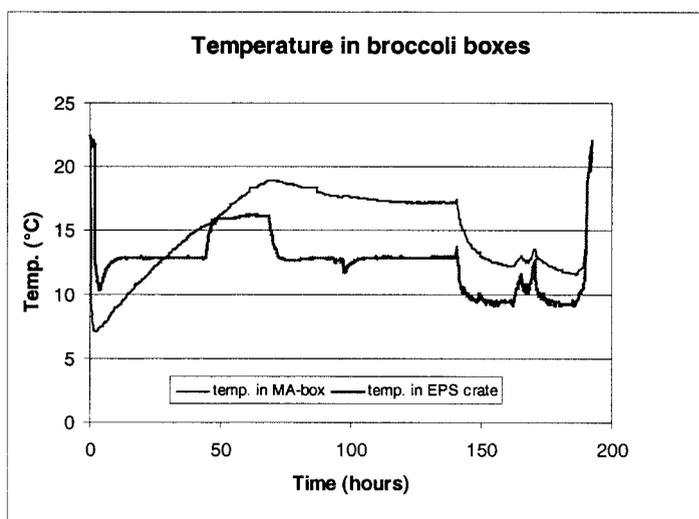


Figure 1 shows that the temperature of the broccoli packed in EPS-crates approximated the temperature of the cold store, while the temperature of the broccoli packed in MA-boxes was 2 °C to 4 °C higher, depending on the temperature in the cold store. This was caused by the heat production of the broccoli and the lesser ability of the stacked MA-boxes compared to the crates to exchange the produced heat. The temperature of the broccoli in the MA-boxes packed at Univeg and stacked on separate stacks was 1°C to 2 °C higher than the temperature of the cold store (data not shown).

The possible negative effect of a higher temperature of the broccoli in the MA-box though, was overruled by the positive effect of the MA-conditions.

Concentrations O₂ and CO₂ in the MA-boxes

Table 4 shows the average concentrations O₂ and CO₂ in the MA-boxes at 12 °C after 5 days storage at ATO-DLO.

Table 4. Average concentrations O₂ and CO₂ in the MA-boxes at 12 °C after 5 days storage at ATO-DLO.

	% O ₂	% CO ₂
MA-box packed at Univeg	13.4	7.1
MA-box packed at ATO-DLO	11.2	8.8

The table shows that due to the differences in temperature because of the way of stacking (see *Temperature during storage*) the concentrations O₂ and CO₂ in the MA-boxes packed at ATO-DLO were more extreme than in the MA-boxes packed at Univeg.

4. Conclusions

From this pilot test we may conclude that the newly developed MA-box indeed retains the quality of broccoli. Further, the discolouration of the stalk ends can be easily reduced to an acceptable level when the stalks are recut with sharp and disinfected knives before packing. Hence, the new package fulfilled its expectations.

Summarizing:

- The MA-box retains the quality of English broccoli better compared to the currently used crate
- The MA-box strongly inhibits the yellowing of the broccoli heads.
- The stalk end discolouration can be minimised for broccoli packed in both MA-boxes and crates by recutting the broccoli with a sharp and disinfected knife before packing.
- The stalk end discolouration of broccoli packed in MA-boxes is stimulated compared to broccoli in EPS-crates. Recutting the stalk ends with sharp and disinfected knives before packing avoids the effect.
- The MA-box strongly reduces the weight losses of the broccoli compared to the crates.
- The possible effect of the MA conditions on the quality of the broccoli in the MA-box strongly overrules possible negative effects of a higher temperature.