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Influence of different packaging types on the quality of chicory

**A comparison between “MA-flowpack” and
“Foodtainer with stretchfilm” packages**

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Confidential

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Influence of different packaging types on the quality of chicory

A comparison between "MA-flowpack" and "Foodtainer with stretchfilm" packages

A study ordered by "The Greenery International"

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1. Summary

The effects on the quality of the packed product of several consumer packages developed for chicory heads were studied at three temperatures (4°C-12°C-18°C). The following package types were tested.

1. MA flowpack package
2. Foodtainer overwrapped with stretchfilm
3. Flowpack package with macro perforations
4. Unpacked chicory (as a reference)

The following quality aspects were studied:

- Greening of the outer leaves (exposure to light)
- Leaf edge browning (necrosis)
- Stem growth
- Decay
- Red discolouration of the vascular bundles and leaves.

The following table gives a qualitative overview of the results of the experiments.

Effects of package types on the quality of chicory					
Package type	Greening	Leaf edge browning	Red discolouration	Stem Growth	Keepability
MA flowpack	++	+++	+++	++	+++
Foodtainer	-	+	+	+	+
Flowpack macroperf.	-	-	--	--	-
Unpacked	--	--	--	--	--

At all studied temperatures the MA flowpack packages showed a strong positive effect on the product quality. An additional positive effect of MA flowpack packages was that MA flowpack appeared to be an excellent protective package capable in preventing the product to turn to green discolouration when exposed to light. The salability period during exposure to light increased from 6 hours for the unpacked product to approximately 18 hours for the chicory packed in MA flowpack packages. Chicory in the current used standard package type for chicory namely foodtainer with stretchfilm, showed significant more greening than chicory packed in MA flowpack.

A flowpack package provided with macro perforations seemed to be no alternative for MA flowpack packages.

The final conclusion is that the quality of chicory is best maintained in MA flowpack packages compared with other tested package types.

2. Introduction

2.1. General

In the last few years some packing companies specialized themselves in Modified Atmosphere (MA) packaging for fresh fruits and vegetables. An important consideration for doing this is that MA-conditions in the package can provide a significant prolonging of the keepability of the packed product.

“The Greenery International” has ordered ATO-DLO to study and quantify the effects of different MA packaging types on the postharvest quality of chicory.

2.1.1. Principles of MA packaging technology

In a MA package the natural respiration of the product is used to realize a change in the gasatmosphere in the package. Due to the respiration the carbon dioxide concentration (CO_2) inside the package increases and the oxygen (O_2) concentration decreases. These altered gasconditions inside the package reduce the respiration of the packed product. As a result of that the rate of ageing processes of the product is reduced.

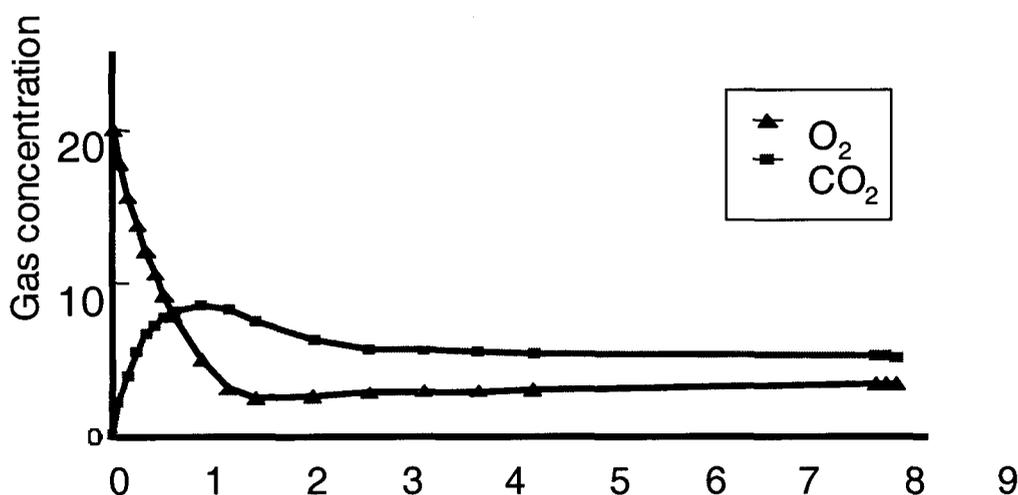


Figure 1: Gasconcentrations in a MA package.

For this reason the product may have a longer keepability.

Films used for MA packages are permeable for the respiratory gases so a certain amount of O_2 and CO_2 is exchanged with the atmosphere outside the package. After a certain period an equilibrium of CO_2 and O_2 concentrations inside the package is reached (steady state). In figure 1 an example of a representative course of the gasconcentrations in an typical MA package is shown. Each product has specific optimal gasconcentrations. At sub optimal gas concentrations the effects on the quality are less. At extreme gas concentrations the product may become anaerobic.

To get the desired O_2 - and CO_2 -concentrations inside the package and at the same time avoiding damaging conditions, a film with a specific permeability must be selected.

The steady state gas levels in a certain MA package are the result of different factors such as:

- temperature
- filmtyp: polymer, thickness
- product properties: ripeness, species, respiration rate
- dimension of the package
- mass of the packed product

The problem (or the art) is how to develop a MA package for every product-market combination wherein steady state gas levels are reached which are favourable for the product quality. When mistakes are made with the packaging material or the dimension of the package an increased level of decay may be the result instead of longer keepability.

2.1.2. Definition of MA

Nowadays not only MA packaging but also active gas packaging of food stuffs is applied. In this report MA packaging is meant to be a passive system i.e. the modification of the atmosphere is created only by means of respiration of the product and not by flushing the packages with external gas mixes.

2.1.3. Input quality

MA packaging is not capable in curing disorders when the input quality of the packed product is not optimal. To get the maximum keepability at the consumers level the input quality of the product is of great importance.

An integral chain approach from grower via packer/exporter until the receiving distribution center is the best guarantee for maintaining product quality.

2.1.4. Environmental aspects of the studied MA packages

In this study the quality effects of a "MA flowpack" package on chicory are compared with both a film wrapped "foodtainer" package and also with unpacked chicory. The "MA flowpack" package is an OPP (oriented polypropylene) bag with specific microperforations that allow exchange of gases through the package. The "foodtainer" package is the current Dutch standard package for retail chicory packages and is also a MA package system. The foodtainer is a foamed polystyrene tray and the stretch film is a PVC-film with a high concentration of plasticizers (ftalates) necessary for the stretching properties of the film.

From an environmental point of view the MA flowpack package is favourable compared to the current standard package. The "flowpack" package is just a polymer bag without a tray. Thus by using the MA flowpack package less packaging material by volume will be wasted. In addition OPP is a polymer that can be combusted clean in incinerators while PVC film contains chlorine and can cause toxic exhaust gases while combusting it. PVC could be reused but in that case it should be separated from other polymers by the consumer at the collecting points of waste materials. This is a rather expensive procedure. Besides that, most consumers cannot distinguish one type of polymer from the other. For these reasons the use of PVC as a packaging material is criticized.

A second reason to call MA flowpack a rather environmental friendly package system is because of by using MA packages postharvest losses are less compared to the post-harvest losses of non-packed products. The energy savings reached by minimizing these kinds of postharvest losses are very substantial.

3. Goal of the study

The research was focused on the determination of the keepability of chicory packed in different package types. The quality aspects that were studied were:

- Stem growth
- Red discolouration
- Microbiological decay (rot).
- Leaf edge browning (necrosis)

In addition the greening of the outer leaves was studied during exposure to light. To accept the higher costs of MA flowpack packaging compared to the costs of the standard packaging a significant positive effect on the keepability should be achieved.

4. Material and methods

4.1. Packages

The packages in this study were: a “MA flowpack” package and a standard “foodtainer with stretchfilm” package. Unpacked chicory was studied as a reference. Each package consisted of 3 chicory heads and the contents of each packages was $\pm 500\text{g}$.

In a separate experiment (pilot experiment) that had been carried out before the main experiment the effects of macro perforated flowpack packages were determined on the quality of chicory compared to the effects of MA flowpack packages and foodtainer packages.

4.2. Determination of quality and keepability

For the determination of the keepability of chicory the following quality parameters were measured during storage:

1. Leaf edge browning (necrosis)
2. Stem growth
3. Red discolouration of the vascular bundles and the leaves
4. Stem end discolouration
5. Greening*
6. Microbiological decay (rot)
7. Off odours (yes/no)

* Heads exposed to light were solely judged on greening.

All quality aspects with exception of “ off-odours” were ranked on a scale from 0-5. Class 0 means fully absence of that aspect. Class 5 means full development of the disorder.

Within this investigation class 2 was determined as the threshold value for salability of the product. So this threshold value was defined as the limit for the keepability. When one of the quality aspects had reached level 2 the chicory was defined not salable anymore.

So the keepability is defined as the time (in days) it took to reach level 2 of any of the relevant measured quality aspects.

At each temperature the quality of the chicory was judged 8 times. Each time at each storage temperature 4 packages per packing type with each 3 chicory heads were opened and judged. The moments of judgement were spreaded in time according to the expected keepability at each storage temperature. This was done to get optimal results.

4.3. Methods

The separate pilot experiment with macro perforated flow pack packages has been carried out at 12 °C. After a storage period of 8 days the quality of the chicory was judged as described before. The greening of the chicory was separately studied during 24 hours of storage at 18 °C in light (1000 lux/m²).

During the main experiment both the packed and the unpacked chicory were stored at 4° - 12° - 18°C without light. Separately, packages were exposed to light during 12 hours per 24 hours at 18 °C.

The mentioned temperatures were chosen because of the following reasons:

- 4 °C : optimal product temperature during a closed cooled distribution chain
- 12 °C : temperature of a refrigerated truck with a mixed load
- 18 °C : temperature during an uncooled distribution chain
- 18 °C + light: supermarket/grocery shelf without cooling

4.4. Gas measurements inside the packages

During storage the concentrations O₂ en CO₂ inside the different types of packages were measured at each storage temperature. The measured values are important because they can explain the quality differences between the chicory package types. The concentrations O₂ and CO₂ were measured with a Chrompack gaschromatograph type 2002.

5. Results

5.1. Pilot experiment

After a storage period of 8 days at 12 °C neither growth, red discolouration or decay was found. The only quality disorder that expressed differently in the different types of packages was leaf edge browning. Because of the surveyability of this report only the data concerning this quality aspect will be discussed in this chapter. The results are shown in table 1.

Table 1: Percentage chicory with leaf edge browning (class 1) and greening in various chicory packages after 8 days storage at 12 °C

	% leaf edge browning (class 1)	Greening (class 0-5) After 24 hours light at 18°C
Unpacked	70	5
Foodtainer	30	4
Flowpack macroperf.	53	4
MA-flowpack	18	2

Table 1 shows the positive effect of the MA flowpack package on the quality of the chicory heads. This was due to the changed gas concentrations inside the packages as the flowpack packages with macro perforations had no altered gas concentrations. The quality of the chicory heads packed in flowpack packages with macro perforations was better compared to the chicory packed in the currently used foodtainers.

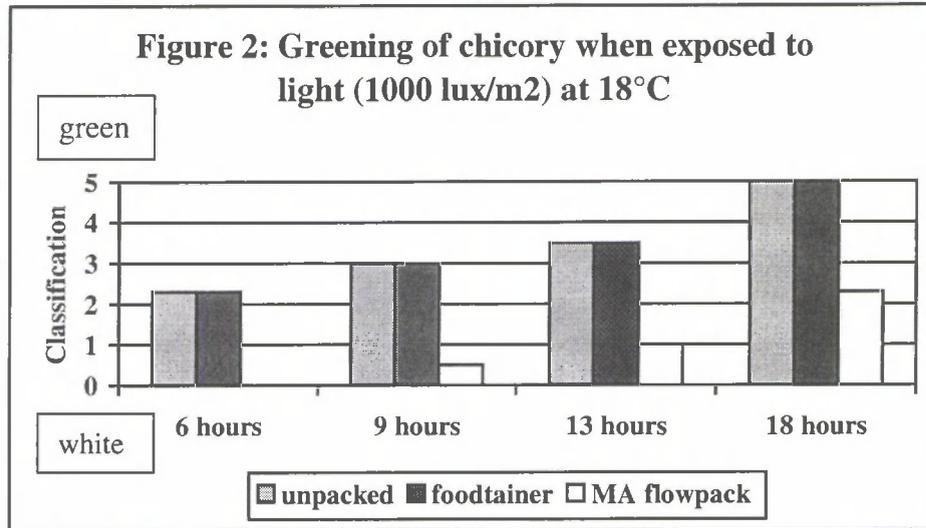
Conclusions pilot experiment

- *At 12°C a flowpack package with macro perforations is less suitable for chicory heads with respect to quality than foodtainers. In this experiment the keepability of the unpacked chicory was the shortest.*
- *The MA flowpack package retains the quality of the packed chicory the best of the tested packages.*

5.2. Main experiment

5.2.1. Greening of the outer leaves

Figure 2 shows the rate of greening of the chicory packed in different types of packages. The measurements were carried out with chicory that had been stored in the dark for 2 days before exposure to light.



The MA flowpack package strongly inhibited the greening of the chicory. Chicory packed in MA flowpack packages was salable for almost 18 hours during exposure to light at 18 °C.

Photo: Green discolouration of chicory heads after exposure to light. On the right MA flowpack.



The rate of greening of unpacked chicory and chicory packed in foodtainers was the same. The chicory was salable for only 6 hours during exposure to light at 18 °C. So MA flowpack is a very favourable method of packaging to reduce greening. Repetitions of that part of the experiment (because of taking good pictures) showed the same effects (data not shown).

Conclusion green discolouration

- *MA flowpack packages considerably inhibit the rate of greening of chicory during exposure to light. The shelf life in light is four times longer.*
- *When both unpacked chicory and chicory packed in foodtainers are exposed to light the product cannot be sold any more after 6 hours because of a too green colour.*

5.2.2. Leaf edge browning

Table 2 shows the effects of temperature and type of package on the leaf edge browning of the chicory. Storage took place in the dark.

Table 2: Time (days) until leaf edge browning of various packed chicory reached class 2. Class 2 is the salability limit in the supermarket.			
	4°C	12°C	18°C
Unpacked	30	9	6
Foodtainer	26	14	9
MA flowpack	38	27	15

At non optimum temperatures (12° en 18°C) the MA flowpack strongly inhibited the leaf edge browning. At 4 °C the results were less pronounced but still very clear. At 4 °C the foodtainer package showed more leaf edge browning of the chicory than unpacked chicory showed. But at 12° and at 18°C the foodtainer package reduced the browning of the chicory more compared to unpacked chicory.

Conclusion leaf edge browning

- *Leaf edge browning of chicory is strongly inhibited when packed in MA flowpack packages compared to unpacked chicory and chicory packed in foodtainers.*
- *At 12 °C and 18 °C the “foodtainer” package has a positive effect on prevention of leaf edge browning of chicory compared to unpacked chicory.*

5.2.3. Red discolouration

Table 3 shows the effects of the applied types of packages on the red discolouration

Table 3: Time (days) until the red discolouration of various packed chicory reached class 2. Class 2 is the salability limit in the supermarket.			
	4°C	12°C	18°C
Unpacked	>38*	7	6
Foodtainer	14	14	>15
MA flowpack	>38	>27	>15

*“>” indicates that class 2 was not reached and that the experiment had been stopped at the mentioned day.

The MA flowpack had a positive effect on the suppression of red discolouration compared to the other two package types. At 18°C the difference between MA flowpack and Foodtainer packages cannot be defined as at 18°C the experiment was stopped after a period of 15 days.

Conclusion red discolouration

- *The MA flowpack package inhibits the red discolouration of the chicory best*
- *At 4 °C the chicory packed in “foodtainer” packages shows more red discolouration than unpacked chicory..*
- *At 18 °C chicory packed in MA packages shows no red discolouration for at least 15 days.*

5.2.4. Stem growth

In table 4 the results of the effects of the packaging types on stem growth of the packed chicory are shown.

Table 4: Time (days) until stem growth from various chicory packagings reached level 2. Class 2 is the salability limit in the supermarket.			
	4°C	12°C	18°C
Unpacked	>38*	9	7
Foodtainer	>38	13	11
MA flowpack	>38	27	15

* “>” indicates that during the experiment at this condition classification 2 never has been reached for this quality aspect.

Stem growth during storage at 4°C is hardly noticeable and differences between package types could not be established. But at both 12°C and at 18°C there is a strong effect on the expression of the stem growth in the different packaging types. MA flowpack packages suppress stem growth very well when this is compared to the effect of the foodtainer packages. Comparison between MA flowpack and unpacked product shows that at 18°C the period to reach classification 2 is doubled; at 12°C this period is even tripled.

Conclusion stem growth

- *The MA flowpack package suppresses stem growth better than the other tested package types. This is valid for both 12° and for 18°C storage temperature. At a storage temperature of 4°C no differences between package types could be established.*
- *A foodtainer package slows down the stem growth slightly when compared with unpacked chicory.*

5.2.5. Off odours, decay and stem end discolouration

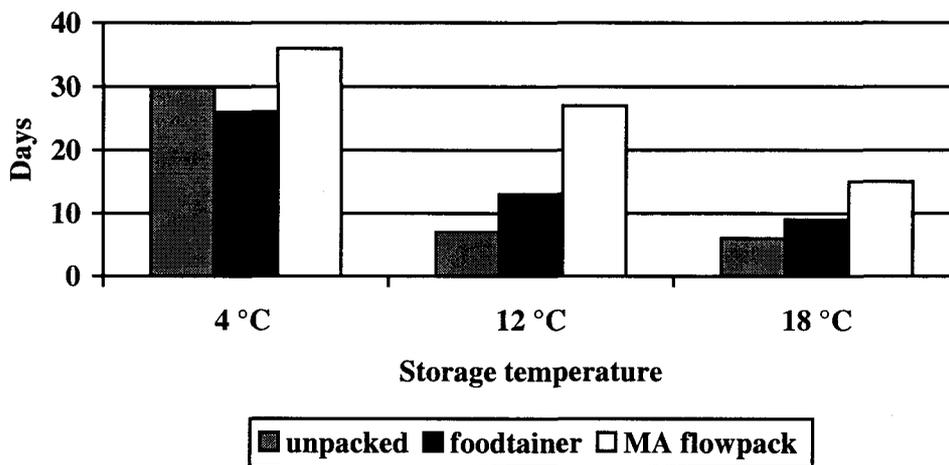
During the experiment no differences between package types could be determined with respect to off odours, decay and stem end discolouration

5.2.6. Keepability

The keepability of the chicory in the various package types is determined by means of a combination of all the judged quality aspects e.g. leaf edge browning, red discolouration, decay and stem growth. The result of this is shown in figure 3.

Figure 3 makes clear that the keepability of chicory is significantly prolonged by using MA flowpack packages. The foodtainer package also offers some benefits but is far less effective compared to the MA flowpack package.

Figure 3: Keepability of chicory



Conclusion keepability

- *The keepability of chicory packed in MA flowpack packages is prolonged at all regarded temperatures compared with the keepability of chicory packed in foodtainers and with the keepability of unpacked product.*
- *Foodtainer packages have a longer keepability compared with unpacked chicory. However at 4°C unpacked product shows a longer keepability.*

6. Final conclusions

Table 5 shows an overview of the results off all relevant quality aspects of various packed chicory.

Table 5: Effects of package types on the quality of chicory					
Packaging type	Greening	Leaf edge browning	Red Discolouration	Stem growth	Keepability
MA flowpack	++	+++	+++	++	+++
Foodtainer	-	+	+	+	+
Flowpack macroporf	-	-	--	--	-
Unpacked	--	--	--	--	--

- Table 5 demonstrates clearly that application of MA flowpack packages gives a big advantage when compared with other tested package systems. Advantages are found for: greening, leaf edge browning, red discolouration and stem growth.
- In these experiments no differences between package type could be indicated for: stem end discolouration, decay and off-odours.
- At higher storage temperatures the effects of MA-packaging are more pronounced.
- The effect of cooling does not exceed the effect of MA packaging. The keepability of MA packed chicory stored at 18°C in the dark is 15 days long, but the keepability of unpacked chicory at 4°C is 30 days. It should be noticed that unpacked chicory when stored at 18°C is only keepable for 6 days.
- The use of macro perforated flowpack packages is no alternative for MA flowpack packaging. The leaf edge browning from the chicory in this package type are even worse compared with the foodtainer package. Comparison with unpacked product shows that macro perforated flowpack packages only have a minor positive effect.
- De foodtainer package is compared with unpacked product also favourable for maintaining product quality. However the protection of this package type effect is far less positive than the protection level that can be obtained by using MA flowpack packages.