Packaging

for Baby Leaf Salad

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University of Aarhus

Food Science

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Procedure

Packaging experiments were carried out using a mix of baby leaf salad containing rocket leaves (*Eruca sativa* Mill.), lamb's lettuce (*Valerianella locusta*), iceberg salad (*Lactuca sativa* L. *var. capita* L.) and red beet leaves (*Beta vulvaris*) for 6 days at 10 ºC.

The salad (100 g) was packed in bags (30 cm outer length / 26 cm inner length x 17.5 cm in width) made from different packaging materials. The packaging material varied in type (biodegradable / non-biodegradable), thickness, permeability with regard to oxygen, carbon dioxide and water, perforability, transparency, rigidity and sealing ability.

Two types of film where especially suitable for packaging baby leaf salad. Those two types gave the best gas composition during the trial with an acceptable weight loss (max. 3%). No sour odour was observed. Two other films where defined as being possible alternatives for packaging baby leaf salad, with higher respiration rates (however).

Contents

Introduction

Baby leaf salad is a product made up of young, delicate leaves harvested at a very active metabolic stage when the daily yield increases dramatically. To maintain product quality after harvest, the product must be handled gently - to prevent physical damage of leaves - rapidly cooled and kept at low temperature with a high humidity to prevent a loss in quality e.g., wilting and yellowing. Modified atmosphere packaging at low temperature may help maintain quality by e.g. reducing respiration that slows down degradation of pigments and carbohydrates and reduces the incidence of mould and bacteria rot. Consequently, post harvest quality is maintained by the packaging for a longer period after harvest.

The aim of the trial was to identify which of the films maintained the best baby leaf salad quality at 10 ºC.

Raw material

The raw material was harvested in The Netherlands 5 days before being packed in Denmark. The baby leaf salad was washed in water, dewatered, air dried, packed in plastic lined boxes with a plastic liner on top to prevent moisture loss during transportation and stored at 3 ºC. The boxes were then transported to Denmark at 4 ºC arriving 2 days later. In Denmark the boxes were stored at 4 ºC until the following day and transported to the trial site at 8 ºC. At the trial site, boxes were stored at 7 ºC for another 2 days until packing 5 days after harvest. The quality of leaves was fairly consistent and leaves were reasonably free of defects as seen in the transport box.

Figure 1. Mixed baby leaf salad packed in a plastic lined box with plastic liner on top during transportation.

Box without liner (left)

and close up of salads (right)

Table 1. a Description of the tested films with illustrations

Code	Film type	Degradability	Thickness	Perforation	WVTR	OTR	Appearance
A	Ökopack Film C (d)	Yes	25µm	÷	85	720	transparent, clear, rigid, cracking
B	Ökopack Film C (dp)	Yes	25µm	macro	÷	÷	transparent, clear, rigid, cracking
C	Ökopack Film C (s)	Yes	30µm	÷	75	1085	transparent, clear, rigid, cracking
D	Ökopack Film S	Yes	30µm	÷	250		orange, soft, opaque
E	Ökopack Film S (p)	Yes	30µm	macro	÷	÷	orange, soft, opaque
F	FolioFresh	No	30µm	÷	0,9	1100	clear, transparent
G	FolioFresh (p)	No	30µm	macro	÷	÷	clear, transparent
H	FolioFresh (lp)	No	30µm	laser perf			clear, transparent

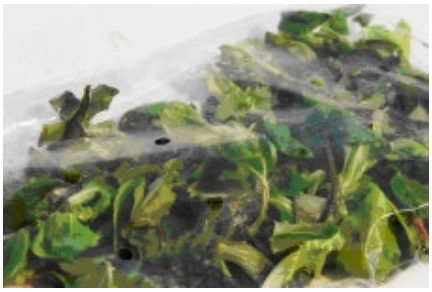
* Water vapour transmission rate (g/m2*day at 85 % rh).

** Oxygen transmission rate (cm3/m2*day*bar at 23 ºC and 50 % rh)

Table 1. b Tested film illustrations

A: Ökopack Film C (d)

B: Ökopack Film C (dp)



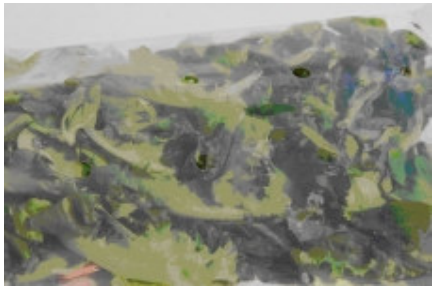
C. Ökopack Film C

D: Ökopack Film S

E: Ökopack Film S(p)

F: FolioFresh

G: FolioFresh (p)



H. FolioFresh (lp)

Packing

The salad (100 g) was packed in bags (30 cm outer length/26 cm inner length x 17.5 cm in width) made from different packaging material. The packaging material varied in type (biodegradable/non-biodegradable), thickness, permeability with regard to oxygen, carbon dioxide and water, perforability, transparency, rigidity and sealing. All films sealed properly. During the packing process no difficulties occurred; it was even extremely easy and fast changing between the film types. All different film types where put on the machine after each other and all films performed extremely well. Neither sealing nor speed were an issue at all. All seals were closed properly, even though in some occasions the leafs were enclosed in the sealing. We also observed slight variations in the homogeneity of the film and since most biodegradable films have a large sealing window, these variations in homogeneity did not prove to be a problem in the packaging process.

The order in which the various films were used to package the salad is given in **Table 1**. The raw material was weighed into individual boxes by hand, transferred manually into the packaging room and fed manually into the tube of the packaging machine. The temperature of the salads at packaging varied between 6.7 ºC and 12 ºC. After packaging, bags were stacked in foam boxes vertically, when appropriate, otherwise horizontally (pillow packs) to prevent physical damage to leaves. The foam boxes were then transferred to the cooling room held at 7 ºC and kept without a lid until transportation to the research station, which was approx. 20 min away. During packaging, bags without macro perforation (A, C, D, F, H) were inspected for seal quality and only bags that sealed properly were used for the trial.

During handling and packing, it was difficult to prevent physical damage of leaves even although manual weighing and filling of the filling sleeve was done gently. After packing, additional physical damage of leaves probably occurred in the bags without the pillow pack effect e.g. those with macro perforation (**Figure 2**) even although the foam boxes were only half-filled and care was taken to prevent damage of leaves.

Figure 2. ‘Pillow packaging’ is necessary to protect delicate leaves such as baby leaf salads, against physical damage during handling and transportation. Excess gas within the pillow pack gives a physical protection.

pillow packaging (left) and ‘normal’ packaging (right).

Storage

The baby leaf salad was stored in a room at 10 ºC for 6 days. The room temperature was a little higher than the product temperature, which varied from 9.1 ºC to 9.8 ºC with an average of 9.6 ºC. The bags were stored on shelves in randomised order on storage containers (**Figure 3**). Repeated measures of oxygen and carbon dioxide were taken with a Checkmate from PBI-Dansensor on 4 bags from each packaging material. The weight of these same bags was recorded and weight loss determined.

Figure 3. Storage of baby leaf salad at 10 ºC

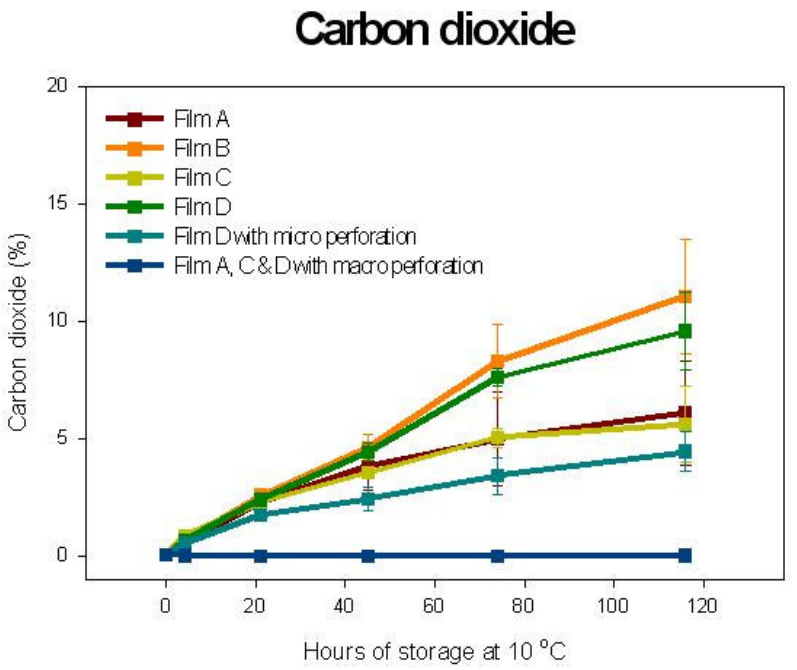
Oxygen and carbon dioxide concentrations

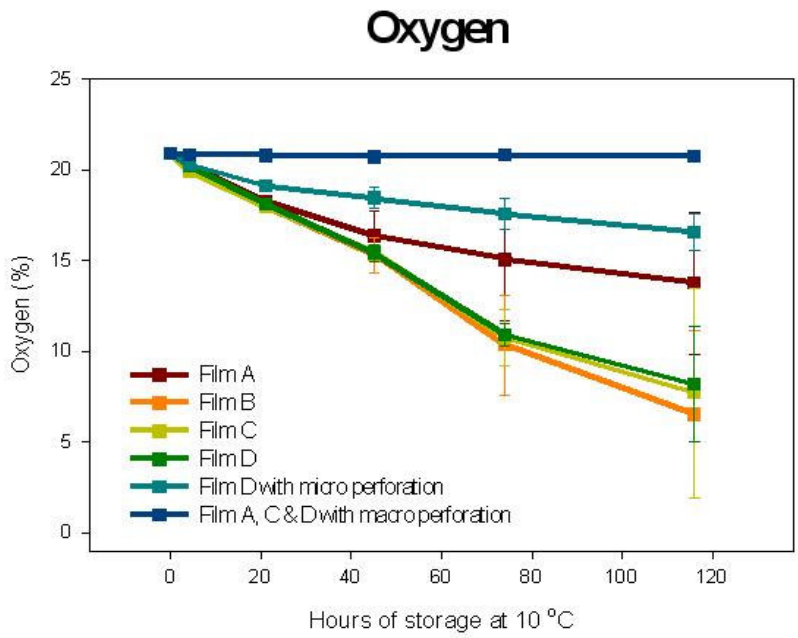
In general, there was variation between the packaging material and the ability of the salad to modify the atmosphere inside the pack (**Figure 4**). No modification was obtained with macro-perforation. Here the oxygen and carbon dioxide concentrations were similar to that of ambient air. After 6 days of storage at 10 ºC, the oxygen concentration had dropped to 16.6% in film H, to 13.7 % in film A and to 6.5 to 8.2% in films C, D, F. At the same time, the CO2 concentrations had increased from 4.5 to 6.1% in films H, E and A and from 9.6 to 11.1 % in films C, F, G and H .

At day 6 there were significant differences between the oxygen concentrations of the macro-perforated films and the micro-perforated film. For carbon dioxide, there were significant differences between film C and the macro-perforated film H and films D and E. There were no differences between F and C as indicated by overlapping deviations.

Films C and F gave similar gas modification within the pack. Film D also modified the oxygen concentration to levels similar to films C and F but had lower levels of carbon dioxide. Film D therefore gives new opportunities for the packaging of fresh fruits and vegetables that benefit from reduced oxygen levels but are sensitive to high carbon dioxide levels.

Figure 4. Changes in the oxygen and carbon dioxide concentration during repeated measuring of packaged baby leaf salad at 10 ºC.

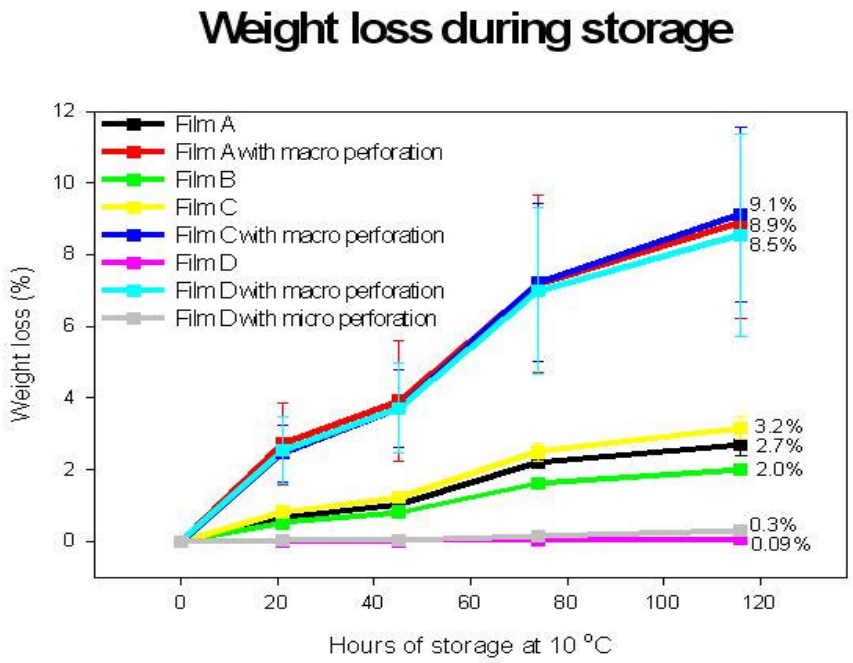




Weight loss

The films varied in water vapour transmission rate from high to very low (**Table 1**). These differences affected the weight loss during post-harvest storage (**Figure 5**). The weight loss was grouped into four distinct groups, a group of salad that lost around 9 % of the weight (the macro-perforated films), two around 3% (A and D), one around 2 % (C) and two around 0.2% (F and H). Several factors lead to weight loss during storage of fresh fruits and vegetables, e.g. water evaporation and respiration. In this trial, water evaporation was the main cause of weight loss as the relative humidity increased from approximately 78 to 88 % in the storage room clearly indicating a great loss of water from the product.

Figure 5. Weight loss (%) in packaged baby leaf salad during 6 days storage at 10 ºC. Average of 4 samples per film type with standard deviations.



Quality measures

The visual appearance of the packed baby leaf salad was evaluated at packing stage and after 6 days of storage (**Figure 6**). The packaging material varied in transparency, rigidity and noise when touched (**Table 1**). During storage, some of the products wilted due to water loss, became rotten and leaves adhered to the packaging material (**Figure 6 and 7**). Condensation on and water in the bags were also observed during storage. Some of these quality factors were obvious from photos (**Figure 6**); however, photo documentation only showed part of the change in product quality.

Figure 6. Photo documentation showing bags with packed baby leaf salad.

A:

Day 0

Day 6

B:

Day 0

Day 6

C:

Day 0

Day 6

D:

Day 0

Day 6

Day 6 after opening

E:

Day 0

Day 6

F:

Day 0

Day 6

G:

Day 0

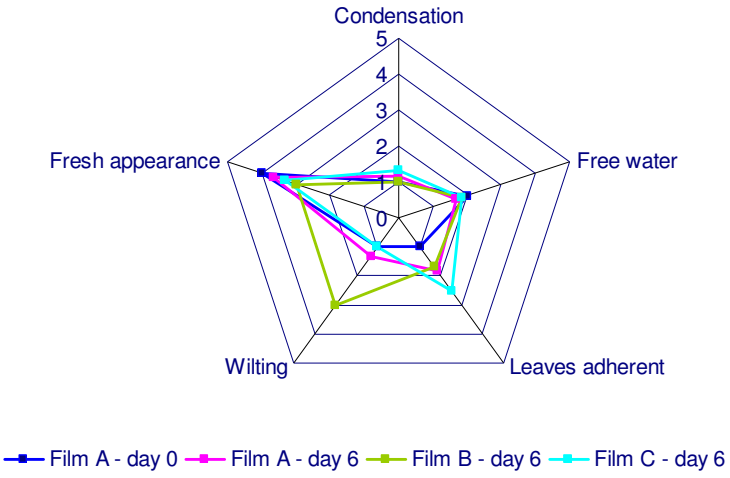
Day 6

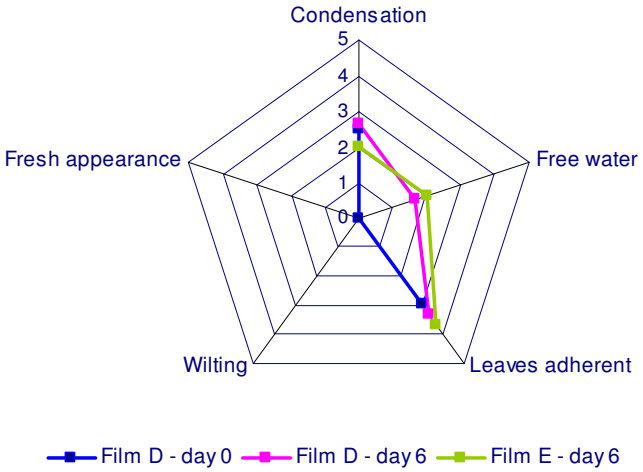
H:

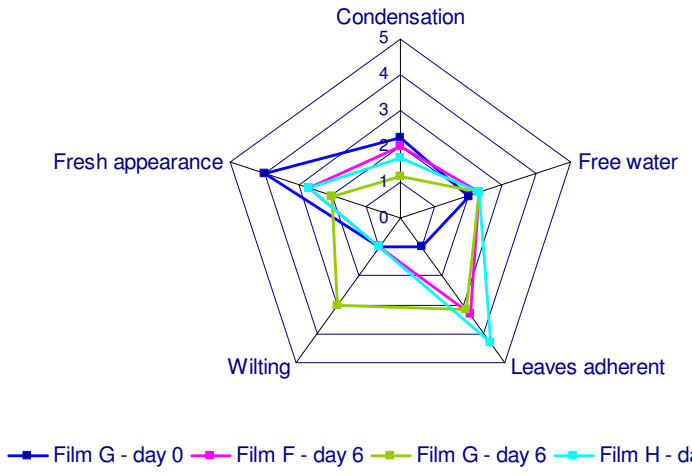
Day 0

Day 6

Figure 7. Expert evaluation of the visual appearance of packed salad at day 0 and 6 on a scale from 1(low) to 5 (high). Average ratings of 3 samples per packaging material.

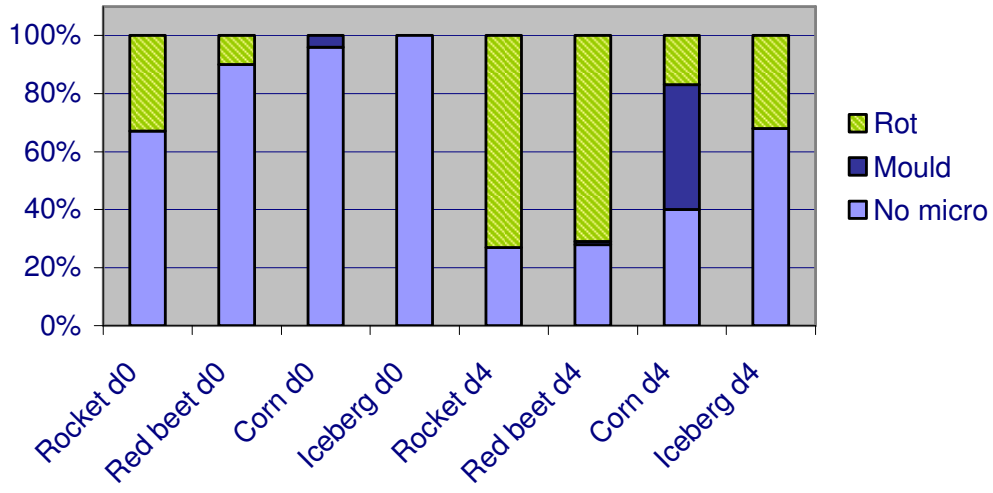






Only films A,B,C and F,G,H were evaluated for all characteristics. Films D and E's being not transparent made it impossible to evaluate the wilting and freshness of the produce without opening the bag and the product looked unappetizing and old especially when the leaves adhered to the packaging material (**Figure 6**). However, when bags were opened, product freshness increased dramatically. Being not transparent makes films D and E unsuitable for packaging baby leaf salad as appearance is the most important quality factor at POS.

Figure 8. The relative distribution of mould and rot in baby leaf salad on day 0 and 4. Average of 3x30 g samples at day 0 and of 24X30 g samples at day 4.

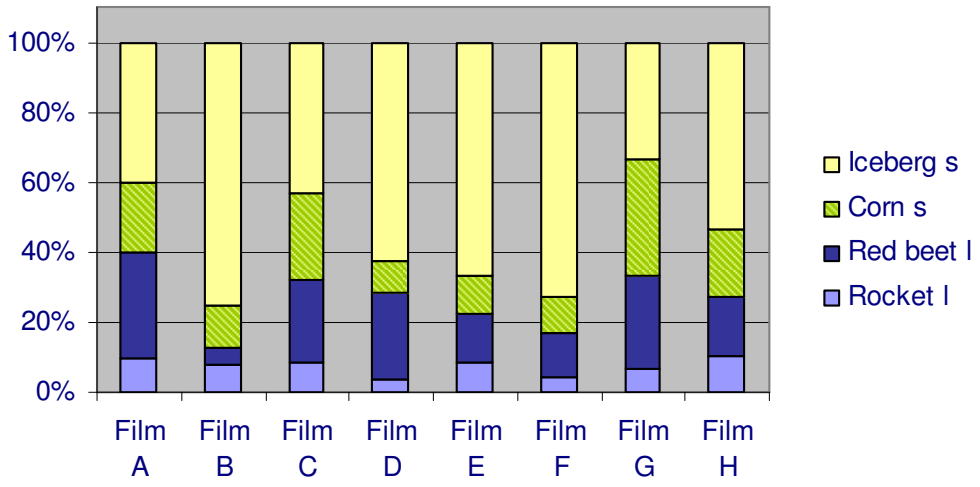


The clearness and sound of films A,B,C had a positive influence on the evaluation of freshness of the baby leaf salad. Scores for condensation and free water were low but high for fresh appearance. The fresh appearance attribute took only the appearance of the non-rotten leaves into account. All samples contained rotten leaves at day 0 and day 4 (**Figure 8**) especially those samples with a high content of rocket and red beet leaves **(Figure 9**). The rotten leaves impacted on several of the visual quality attributes e.g. water, adherent leaves and wilting, especially when the red beet leaves were present in high quantities. During the rotting process, juice is released from leaves and this affected the water score. Wilting juices released, together with rot leaves, adhering to the packaging material, cause an unappetizing appearance.

Figure 9. Physical damage that eventually developed into rot in iceberg salad and red beet leaves. Aging of lamb's lettuce with yellowing, mould and rotten leaves.

The baby leaf salad packed in films F,G,H scored higher on condensation, free water and adherent leaves and lower on fresh appearance than the salad packed in A,B,C (**Figure 9**). However, the data was not exposed to statistical analysis and they can only be used as a rough guideline for further experiments with baby leaf salad packaging. Clear wilting was observed in films G and B at day 6 indicating that macro-perforated film is not suitable for the packaging of salad greens, as it has no natural barrier for moisture loss.

Figure 10. The relative distribution of baby leaf salad. Average of 3 samples taken at day 4.



Sensory evaluation of the baby leaf salad was difficult because the percentage of baby leaf type varied between bags (**Figure 10**) and some salad type rotted faster than others (**Figure 9**) and this affected the overall quality and the incidence of rot, mould, yellowing etc. For this reason, no data is given on sensory quality during storage. Films C and F were, however, the most suitable films for packaging of baby leaf salads from the data on oxygen, carbon dioxide and weight loss and the fact that fermentation odours did not develop in the packs.

Conclusions

Baby leaf salad has a very short storage life. Only first-class quality salad is suitable for packaging. Five days post-harvest storage at variable temperatures before packaging is too long.

Rocket leaves and red beet leaves are prone to physical damage during handling and packaging

Physical damage of leaves must be prevented. A packaging system that prevents physical damage must be chosen.

Macro-perforated film is not suited for packaging baby leaf salad for several reasons:

- Macro holes cannot create the pillow pack bag.
- Macro holes cannot hold product water. This causes product wilting.
- Macro holes allow a free exchange of oxygen and carbon dioxide, thus no modification of the atmosphere surrounding the baby leaf salad.

Films D and E are not suitable for packaging baby leaf salad. Lack of transparency prevents consumers from evaluating appearance at purchase.

Films A,B,C as well as F and H are suitable for packaging baby leaf salad. In this particular experiment, films C and F gave the best gas composition without too high weight loss (max. 3%). No sour odour was observed but it may occur at higher respiration rates. Films A, B and H would then be alternatives.