ATMOSPHERE MANIPULATION INSIDE THE PACKAGE (MAP-CAP)

Peran Pengemasan

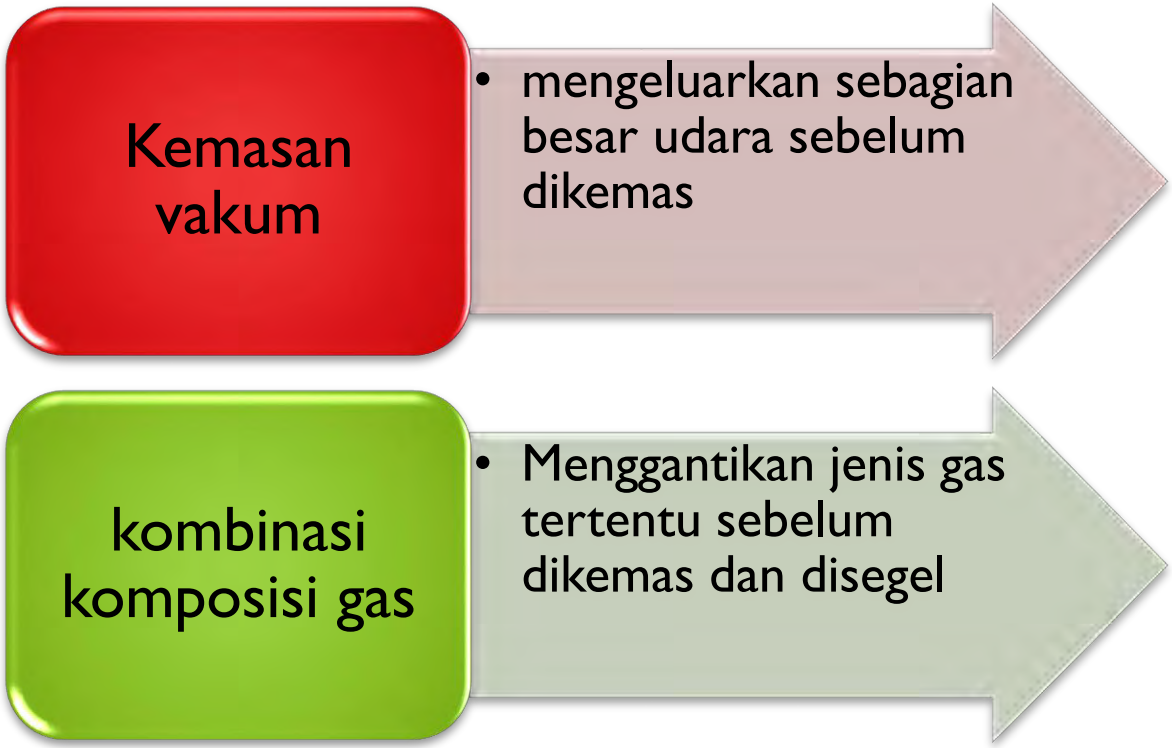
Masa simpan suatu produk pangan yang rawan rusak dibatasi oleh beberapa faktor, indikator kerusakan dapat dilihat pada perubahan aroma, rasa, warna, dan tekstur

Suatu kemasan dapat melindungi produk dari kerusakan fisik, kimia, dan biologi

Selain itu, kemasan juga berfungsi sebagai sistem penahan terhadap oksigen, kelembaban, komponen volatil, dan mikroorganisme dari lingkungan

Sebagai penghalang antara produk pangan dan kondisi lingkungan

Jenis manipulasi atmosfer dalam kemasan



The Types of Atmosphere Manipulation Inside The Package

1. Controlled Atmosphere Packaging (CAP)
2. Modified Atmosphere Packaging (MAP)
3. Vacuum Packaging

Controlled atmosphere (CAP)
Modified atmosphere (MAP)

- addition or removal of gases from storage rooms, transportation containers or packages
- manipulate the levels of gases such as oxygen, carbon dioxide, nitrogen, etc.,
- achieve an atmospheric composition different to that of normal air around the food (Floros, 1990).

PRINCIPLES OF CAP/MAP

to extend the shelf life of food products

to prevent (or at least retard) any undesirable changes in the wholesomeness, safety, sensory characteristics, and nutritive value of foods.

MAP achieves the above objectives based on three principles:

1. It reduces undesirable physiological, chemical/biochemical and physical changes in foods
2. It controls microbial growth
3. Just like any other packaging technique, it prevents product contamination.

The three main gases used in MAP are nitrogen (N_2), oxygen (O_2), and carbon dioxide (CO_2).

THE DIFFERENCE BETWEEN CAP AND MAP

CAP:

The development and maintenance of a precise combination of gases in the environment surrounding the food production throughout its shelf life

MAP:

The initial application of an atmosphere other than air with no further control of the atmosphere

METHODS CREATING MA CONDITIONS

Commodity-generated (pasive MA)

MA can passively evolve within a hermetically sealed package as a consequence of commodity's respiration.

Active Modified Atmosphere

This is done by pulling a slight vacuum and replacing the package atmosphere with a desired mixture CO_2, O_2 and N_2. Other methods of active MA is by using O_2 or CO_2 scavenger or emitter.

The term CAP usually is applied to packaging of respiring food products:

- Fresh meat
- Poultry
- Fish

or

- Foods with respiring biological contaminant such as microorganisms

MAP and CAP

is called also

GAS FLUSHING

→ Insertion of gases to replace atmosphere inside the package

Modified Atmosphere Packaging

Apa sih MAP itu?

- Mengubah komposisi gas di atmosfer yang ada di sekitar produk pangan (dalam kemasan atau ruang), dengan tujuan untuk memperlambat :

Prinsip kerja MAP

- Menggantikan sejumlah kandungan udara tertentu dengan campuran gas lainnya.
- Tingkat keefektifan MAP tergantung pada:
  1. Jenis produk pangan
  2. Kualitas dasar bahan mentah
  3. Campuran gas
  4. Suhu ruangan
  5. Higienitas selama pengolahan dan pengemasan
  6. Perbandingan (rasio) volume gas dan produk
  7. Jenis dan tipe kemasan

Keunggulan Aplikasi MAP

- Memperlama masa simpan produk pangan
- Dapat meningkatkan kualitas kemasan tembus pandang
- termasuk dalam kemasan berlapis yang higienis, tersegel, dan bebas dari kontaminasi bau
- Dapat meminimalisasi penggunaan BTP lainnya
- Dapat meningkatkan area distribusi produk pangan dan biaya transportasi dikarenakan memiliki tingkat ketahanan yang cukup baik dalam kemasan

Kekurangan Aplikasi MAP

- Membutuhkan biaya untuk perlengkapan kemasan gas
- Membutuhkan biaya untuk pengisian jenis gas tertentu
- Membutuhkan biaya untuk analisis komposisi gas apakah sudah tepat belum
- Meningkatkan volume kemasan sehingga berakibat terhadap jumlah produk dalam pengiriman
- Keunggulan MAP akan hilang ketika kemasan tersebut bocor atau pecah

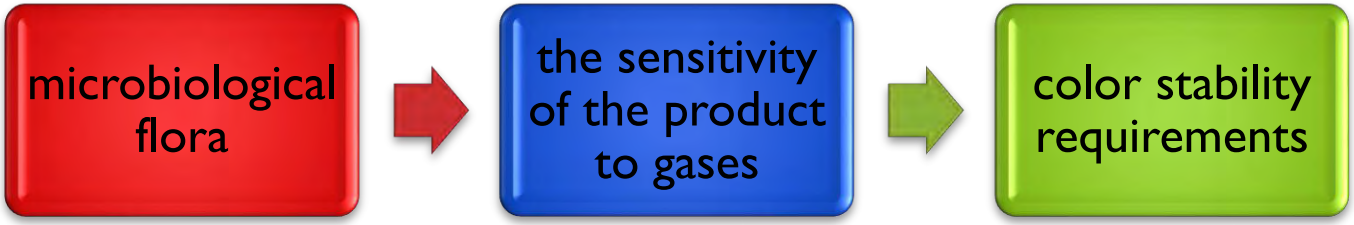
Jenis Gas yang digunakan dalam MAP

- Ada 3 jenis gas yang biasanya dipakai dalam sistem MAP yaitu **oksigen** (O_2), **karbondioksida(CO_2)**, dan **nitrogen(N_2)**.
- Untuk produk yang tidak mengalami respirasi, dimana penyebab utama kerusakan adalah mikroba, bisa digunakan sekitar 30–60% CO_2, atau mungkin menggunakan gas N_2 murni (jika sensitih terhadap O_2) atau menggunakan kombinasi keduanya.
- Untuk produk pangan yang terdapat sistem respirasi, penggunaan 5% CO_2 dan O_2 biasanya digunakan untuk meminimalisasi pross respirasi yang terjadi.

The main gases used in MAP

- These three gases are used in different combination according to the product and the needs of manufacturer and consumer

- The choice for a particular combination is influenced by the:



Carbon dioxide (CO_2)

- CO_2 merupakan jenis gas yang banyak dipakai dalam sistem MAP dikarenakan memiliki sifat bacteriostatic dan fungistatic.

- Beberapa penelitian menunjukkan mekanisme penghambatan pertumbuhan mikroba sangat ditentukan oleh kadar CO_2.
  (Devlieghere *et al.* 1998)

- Rasio (perbandingan) antara volume gas dan produk pangan berada pada kisaran 2:1 dan 3:1 (volume gas 2 atau 3 kali lebih besar dari volume produk pangan).

Nitrogen (N_2)

- N_2 is an inert and tasteless gas.
- Mostly used in MAP as a filler gas because of its low solubility.
- N_2 is almost insoluble in water and fat and will not absorb into the food product, and therefore counteracts package collapse as caused by dissolved CO_2.
- N_2 is used to displace O_2 from air in packages with O_2 sensitive products, to delay oxidative rancidity, and as an alternative to vacuum packaging, to inhibit the growth of aerobic microorganisms.

Oxygen (O_2)

- The use of O_2 in MAP is normally set as low as possible to inhibit the growth of aerobic spoilage bacteria.
- O_2 (around 30%) in the atmosphere for lean fish species has been used to reduce drip loss and colour changes.
- For respiring products O_2 is included in the atmosphere to prevent anaerobic respiration.

The gases used in MAP/CAP:

O_2 : - preserve the red color of meat

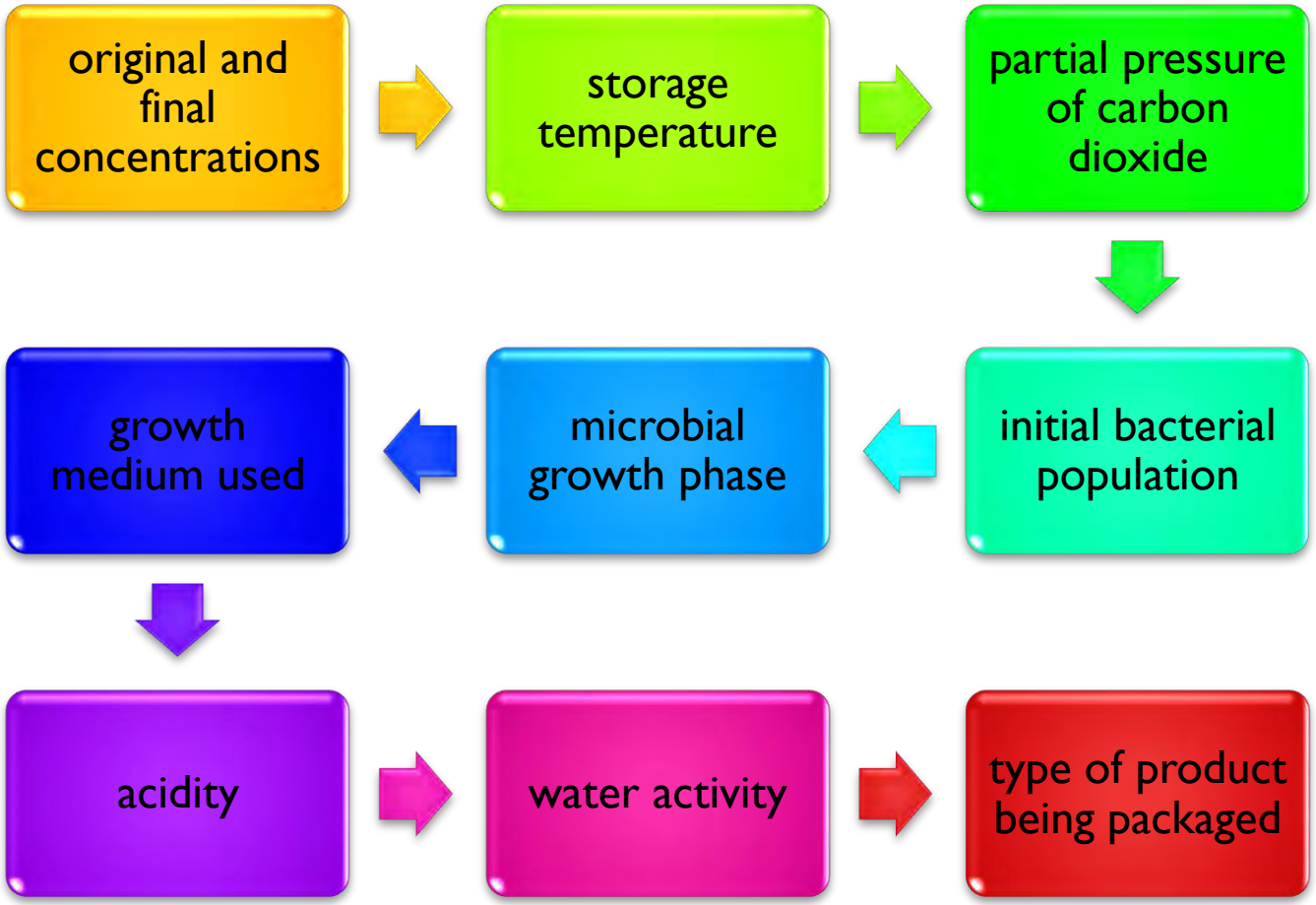
- avoid deterioration by anaerobic microorganism

CO_2 : - avoid the development of molds and bacteria

N_2 : - avoid rancidity

- avoid deterioration caused by molds

- The effectiveness of this gas is influenced by its



Temperatur (suhu)

Untuk mencapai efek antimikroba yang optimum, suhu penyimpanan harus diatur serendah mungkin

Tingkat solubilitas CO_2 akan mengalami penurunan bersamaan dengan meningkatnya suhu lingkungan

Pengaturan suhu yang tidak sesuai dapat mengurangi efektivitas penggunaan gas CO_2

Mekanisme penghambatan dengan CO2

- Tergantung pada kapasitas buffer yang terdapat dalam produk pangan, keberadaan CO_2 dapat mengurangi nilai pH dari suatu larutan, sehingga mikroba akan sulit tumbuh
- CO_2 juga dapat masuk ke dalam sel mikroba, kemudian mengganggu fungsi dari membran
- ion bikarbonat yang dihasilkan dari reaksi hidrasi CO_2 diketahui dapat menghambat kerja metabolism enzim
- Pengaruh yang terjadi pada mikroorgansime terjadi pada peningkatan fase lag dan penurunan fase log pada sistem pertumbuhan logaritmik mikroba

MAP for non-respiring foods

Table 28.1 Modified gas atmospheres commonly used for some non-respiring food products (Dodds, 1995)

Commodity	N_2 (vol%)	CO_2 (vol%)	O_2 (vol%)
Oily fish	40–60	40–60	
White fish		60	40
Crustaceans		80–100	
Red meat		15–30	70–85
Poultry	70–80	20–30	
Bakery and pasta	20–50	50–80	
Cheese	30–100	0–70	
Coffee	100		
Potato chips	100		

MAP for fresh foods

Table 28.2 Optimal gas atmosphere for some fresh produce commonly packaged under MAP conditions (Gorney, 2003)

Commodity	O_2 (vol%)	CO_2 (vol%)
Broccoli florets	2–3	6–7
Shredded cabbage	5–7.5	15
Carrot sticks	2–5	15–20
Chopped romaine lettuce	0.5–3	5–10
Diced onion	2–5	10–15
Potato	1–3	6–9
Apple	<1	4–12
Kiwifruit	2–4	5–10
Strawberry	1–2	5–10
Watermelon cubes	3–5	10

Examples of food shelf life under MAP and air

PRODUCT	Temperature	Shelf life under MAP	Shelf life in AIR
Toast bread	Room	2-3 months	10 days
Cake	Room	40-60 days	-[a]
Croissant, milk bread	Room	6 weeks	Several days
Pizza	4-5°C	30 days	Several days
Hamburger, hot dog rolls	4-5°C	30 days	1 week
Cakes with cream	Room	25-30 days	-
Emmenthal	2-4°C	4-5 weeks	A few days
Bovine mozzarella	2-4°C	6-8 days	3 days
Robiola, Crescenza	2-4°C	3-4 weeks	1 week
Cheese slices	2-4°C	2-3 months	2-3 months
Gorgonzola	2-4°C	30 days	10 days
Parmesan in pieces	2-4°C	40-60 days	-

[a] - means that air was never used to store product.

MAP for dairy products

Whey cheese

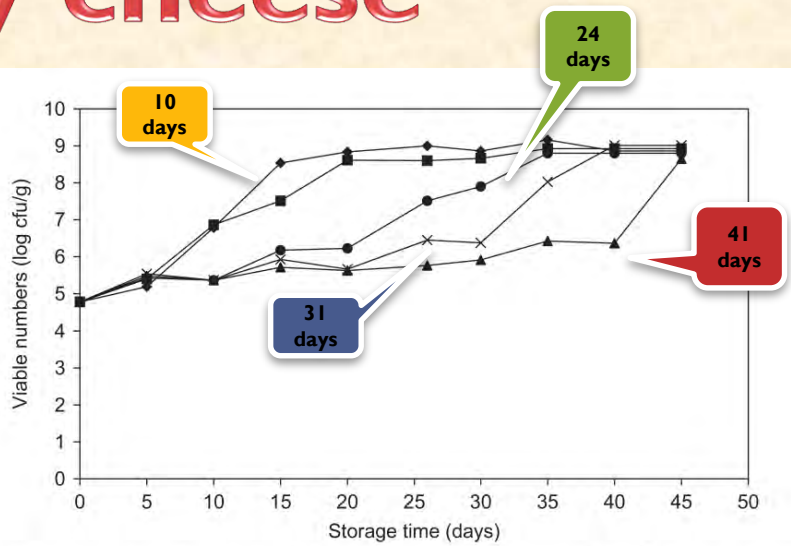


Fig. 1. Effect of packaging conditions on meshophilic bacteria in Myzithra cheese during storage at 4 °C. ◆ A: control (air), ■ B: vacuum, ● C: 20% CO_2/80% N_2, ▲ D: 40% CO_2/60% N_2, × E: 60% CO_2/40% N_2. (SD = ±0.28–0.63). Data presented are the means of two different experiments run on di

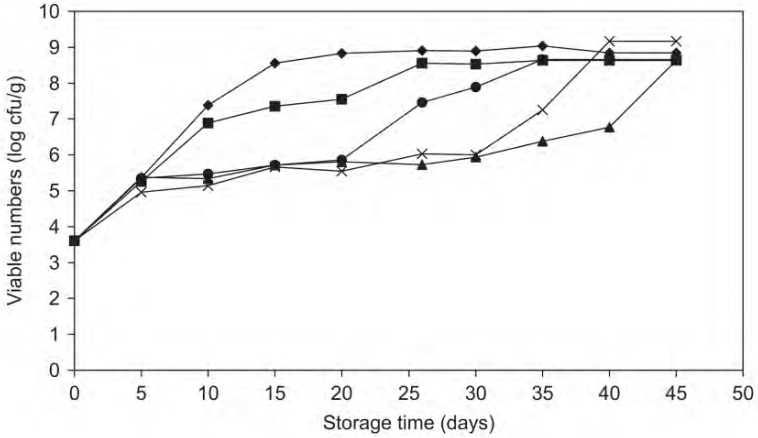


Fig. 2. Effect of packaging conditions on psychrotrophic bacteria in Myzithra cheese during storage at 4 °C. ◆ A: control (air), ■ B: vacuum, ● C: 20% CO_2/80% N_2, ▲ D: 40% CO_2/60% N_2, × E: 60% CO_2/40% N_2. (SD = ±0.16–0.43). Data presented are the means of two different experiments run on different occasions.

Dermiki et al., 2008

Mold and yeast

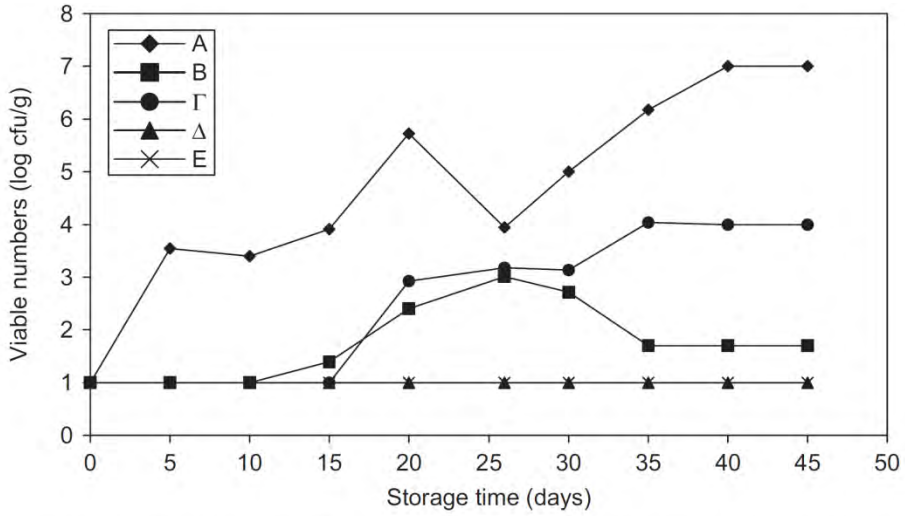


Fig. 5. Effect of packaging conditions on molds and yeasts in Myzithra cheese during storage at 4 °C. ◆ A: control (air), ■ B: vacuum, ● C: 20% CO_2/80% N_2, ▲ D: 40% CO_2/60 N_2, × E: 60% CO_2/40% N_2. (SD = ±0.14–0.34). Data presented are the means of two different experiments run on different occasions.

high CO2 concentrations were very effective for the inhibition of the growth of molds & yeasts.

Dermiki et al., 2008

Odour & taste evaluation

M1: 20 days

Table 1
Odour evaluation of Myzithra whey cheese packaged under various atmospheres during storage at 4 °C

Sample	Storage day							
	0	5	10	15	20	26	30	35
Control	5[a]							
Air	5	5.0±0.3[b]	4.9±0.4	4.5±0.3	2.5±0.1	1±0.1 "Fecal"	0.6±0.1 "Fecal"	0.5±0.1 "Fecal"
Vacuum	5	5.0±0.2	4.7±0.3	4.6±0.4	3.3±0.2	1.6±0.1 "Sour"	1.3±0.1 "Sour"	0.5±0.1 "Sour"
20%CO_2/80%N_2	5	4.8±0.2	4.7±0.2	4.6±0.2	4.3±0.2	3.7±0.3	3.3±0.2 "Flat"	3.1±0.2 "Malty"
40%CO_2/60%N_2	5	4.7±0.3	4.8±0.3	4.5±0.3	4.2±0.4	3.8±0.2	3.5±0.2 "Sour"	3.4±0.1 "Sour"
60%CO_2/40%N_2	5	4.8±0.3	4.7±0.2	4.4±0.4	4.2±0.3	3.8±0.3	3.8±0.3	3.4±0.1 "Sour"

Scoring scale: very good = 5, good = 4, fair = 3, poor = 2, very poor = 1, unfit for human consumption = 0.
[a]Values reported are the means of two different experiments run on different occasions.
[b]± SD values.

Table 2
Taste evaluation of Myzithra whey cheese packaged under various atmospheres during storage at 4 °C

Sample	Storage day							
	0	5	10	15	20	26	30	35
Control	5[a]							
Air	5	5.0±0.2[b]	4.8±0.4	2.1±0.1 "Bitter"	0	0	0	0
Vacuum	5	5.0±0.3	4.7±0.3	4.2±0.3	0	0	0	0
20%CO_2/80%N_2	5	5.0±0.3	4.5±0.4	4.2±0.2	3.5±0.3	3.3±0.2 "Metallic"	0	0
40%CO_2/60%N_2	5	4.8±0.2	4.5±0.3	3.9±0.3	3.5±0.2 "Salty"	3.5±0.2	3.3±0.2 "Flat"	3.3±0.2 "Flat"
60%CO_2/40%N_2	5	4.8±0.3	4.9±0.2	3.6±0.2	3.8±0.2	3.7±0.3	3.6±0.3	0

Scoring scale: very good = 5, good = 4, fair = 3, poor = 2, very poor = 1, unfit for human consumption = 0.
[a]Values reported are the means of two different experiments run on different occasions.
[b]±SD values.

M3: 30 days

M2: 26 days

MAP for meat products

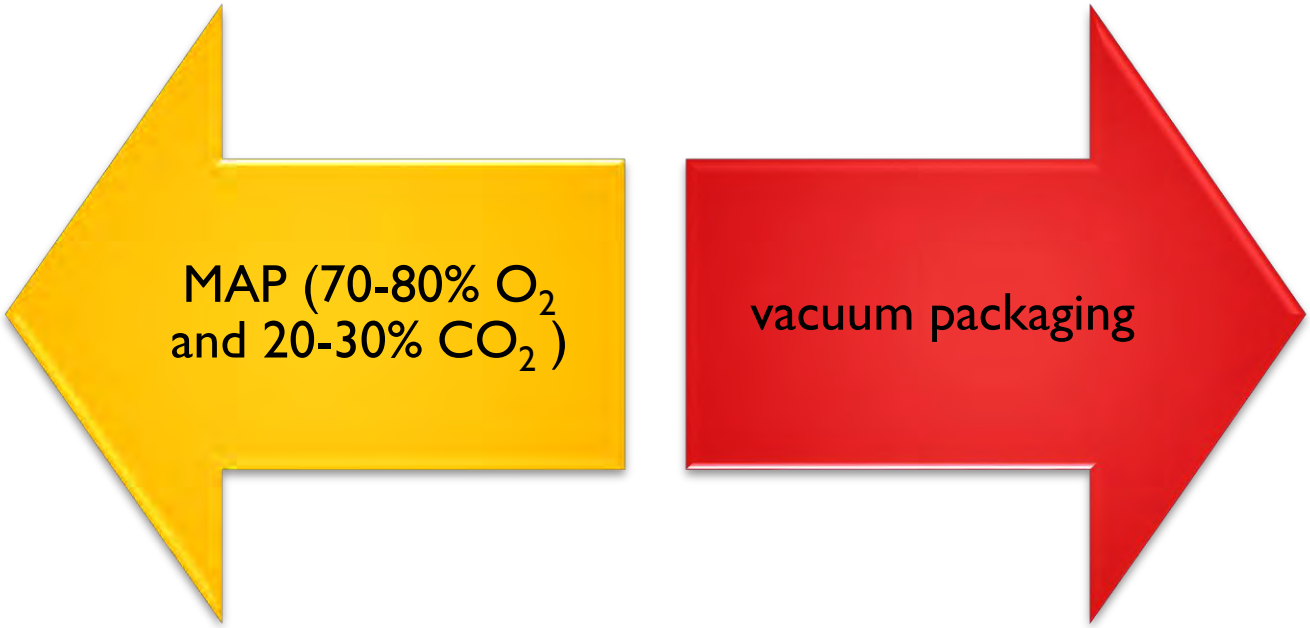
In meat, CO_2 affect the pH :

- CO_2 entering meat tissues → producing carbonic acid → Resulting the lowering pH
- As a result the development of microorganism is retarded or inhibited
- When temperature is decreased the CO_2 solubility in tissues is increased

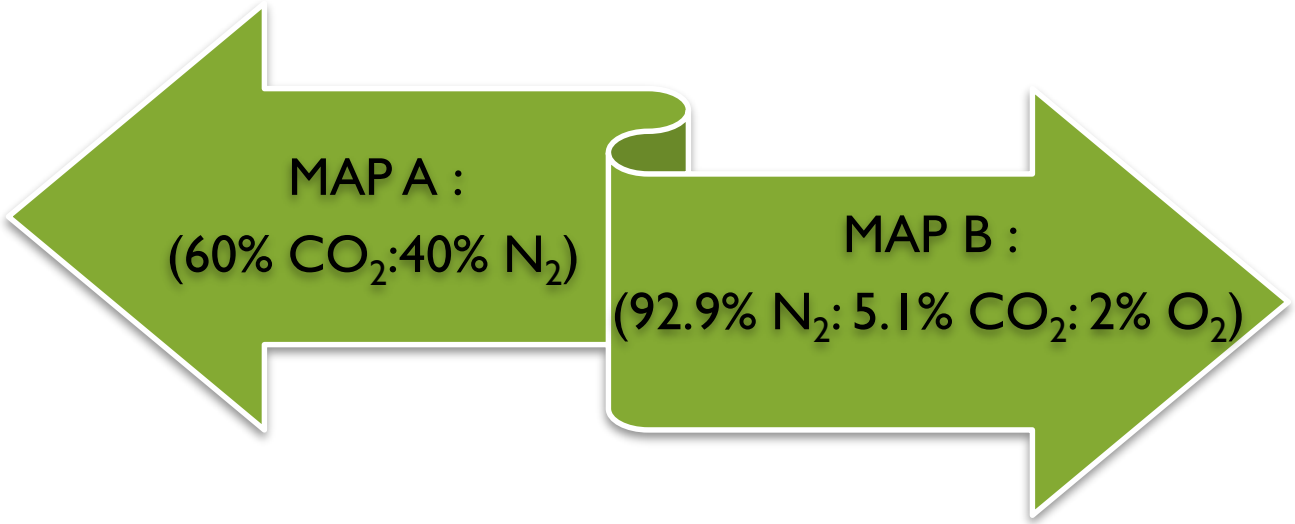
determining shelf life meat

- ✓ The variables that influence the shelf life properties of packaged fresh meat are :

methods for packaging meat



- 5 days at 3° C



Arvanitoyannis et al., 2011

Firmness

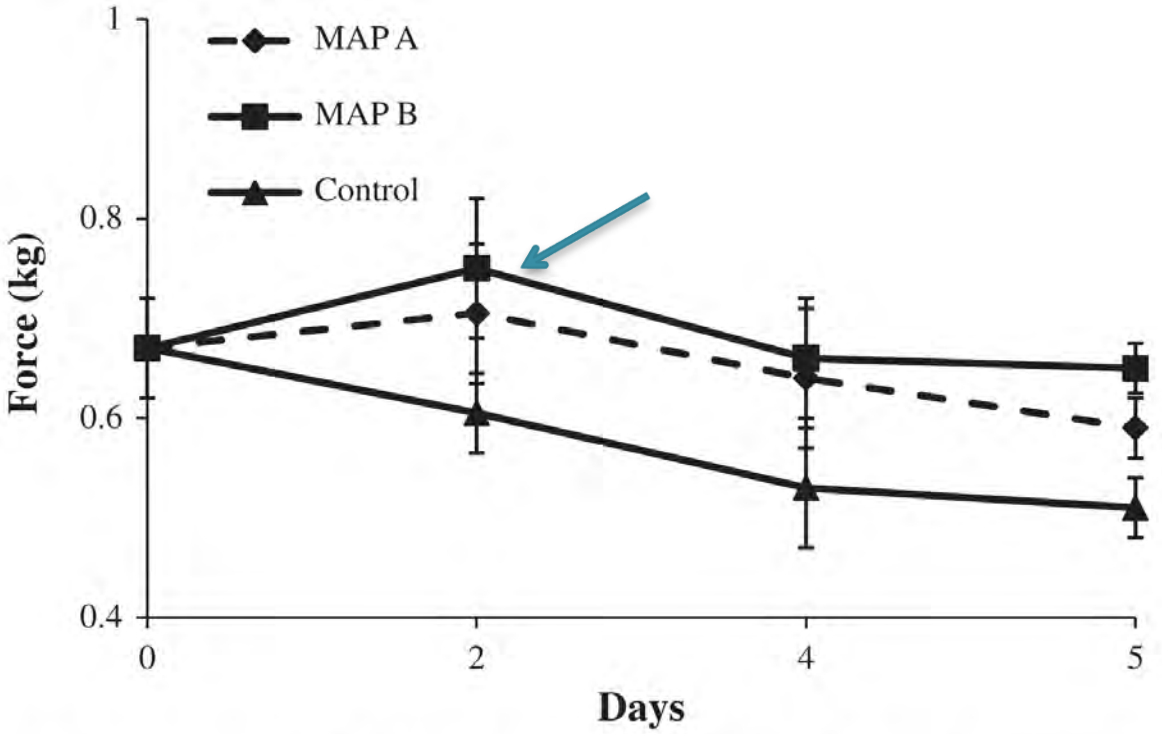


Fig. 1. Firmness values of shrimps stored under MAP A (60% CO_2:40% N_2) or MAP B (92.9% N_2:5.1% CO_2:2% O_2). Error bars indicate standard deviation.

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Pseudomonas

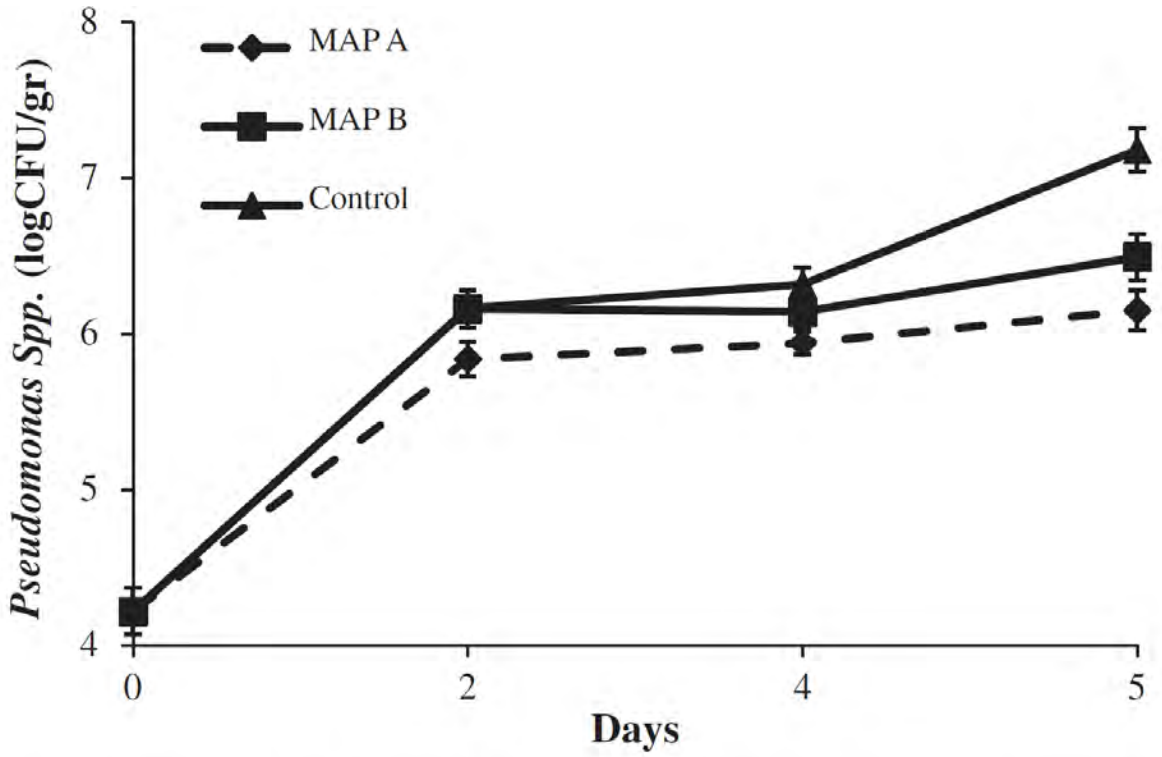

Fig. 3. *Pseudomonas spp.* population on shrimps stored under modified atmosphere conditions (MAP A: 60% CO_2/40% N_2 or MAP B: 92.9% N_2/5.1% CO_2/2% O_2). Error bars indicate standard deviation.

Arvanitoyannis et al., 2011

L value

Table 1
L* value of shrimps stored under MAP A (60% CO_2:40% N_2), MAP B (92.9% N_2:5.1% CO_2:2% O_2) and air for 5 days. Measurements were taken with a chromameter and values are mean ± SD of five measurements. Mean values followed by the same capital letter horizontally and case letter vertically are not significantly different.

Treatments			
Storage duration	MAP A	MAP B	Air
2 days	72.9 ± 0.76^{Aa}	64.83 ± 0.56^{Ca}	67.22 ± 0.57^{Ba}
4 days	71.42 ± 0.58^{Aa}	68.37 ± 0.62^{Bb}	70.06 ± 1.31^{ABb}
5 days	67.85 ± 0.69^{Ab}	64.12 ± 0.85^{Ba}	66.84 ± 0.63^{ABa}

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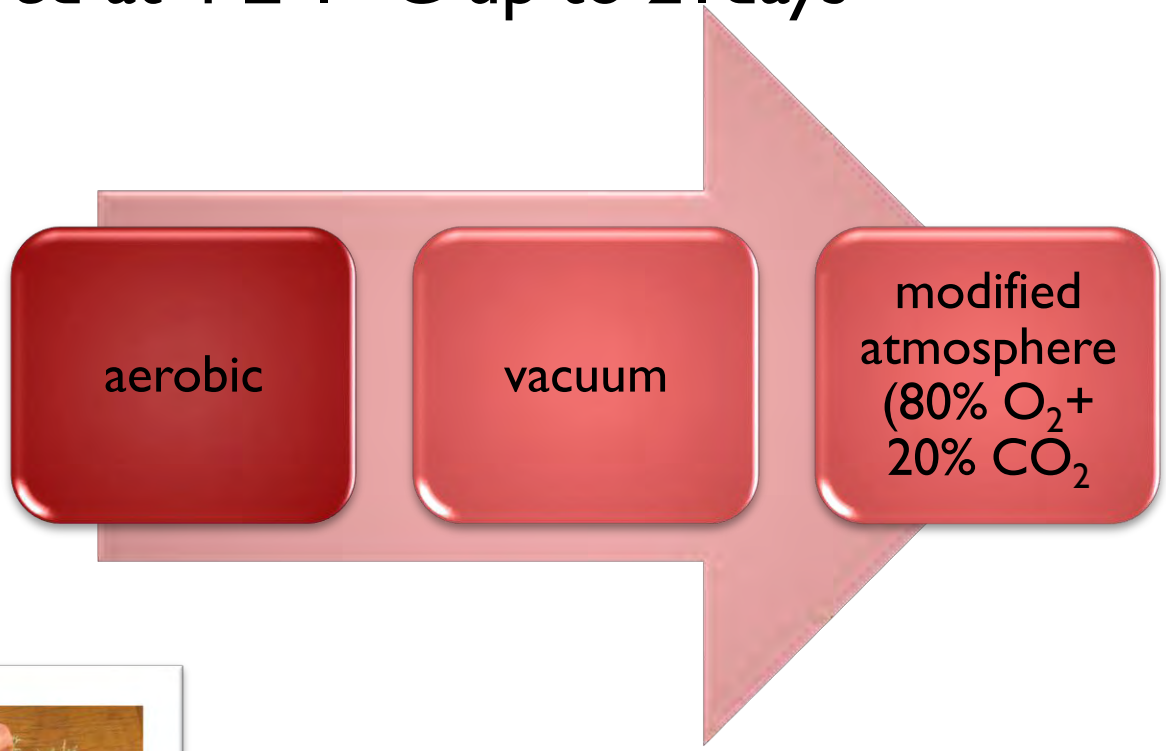
- stored at 4 ± 1° C up to 21days



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Myofibrillar structure

Table 1
Mean (±SE) fibre diameter (μ), sarcomere length (μ) and myofibrillar fragmentation index of buffalo meat packed under different atmospheres and stored at 4 ± 1 °C for upto 21 days

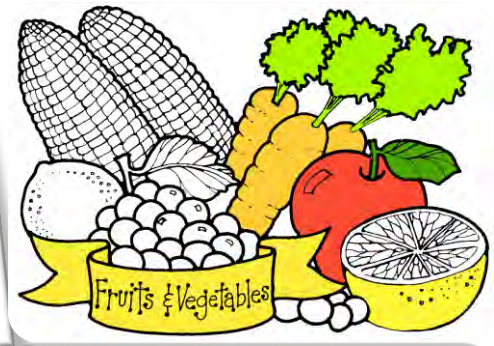
Packaging methods	Storage period (days)					Overall mean (pooled over days)
	0	3	7	14	21	
Fibre diameter (μ)						
Aerobic	$76.79^{g} \pm 1.36$	$71.49^{f} \pm 1.00$	$67.84^{ef} \pm 1.39$	$60.75^{bc} \pm 1.89$	$56.47^{ab} \pm 0.69$	$66.67^{B} \pm 1.27$
Vacuum	$76.79^{g} \pm 1.36$	$62.80^{cd} \pm 1.61$	$57.39^{ab} \pm 1.19$	$53.46^{a} \pm 1.39$	$53.68^{a} \pm 1.32$	$60.82^{A} \pm 1.37$
Modified atmosphere	$76.79^{g} \pm 1.36$	$68.31^{ef} \pm 1.27$	$66.10^{de} \pm 1.60$	$64.29^{cde} \pm 1.17$	$61.02^{bc} \pm 1.71$	$67.30^{B} \pm 1.42$
Overall mean (pooled over methods)	$76.79^{z} \pm 1.36$	$67.53^{y} \pm 1.30$	$63.78^{x} \pm 1.39$	$59.50^{w} \pm 1.49$	$57.06^{w} \pm 1.24$	–
Sarcomere length (μ)						
Aerobic	1.21 ± 0.03	1.51 ± 0.04	1.54 ± 0.03	1.78 ± 0.03	1.84 ± 0.04	$1.57^{A} \pm 0.03$
Vacuum	1.21 ± 0.03	1.56 ± 0.01	1.60 ± 0.02	1.80 ± 0.03	1.93 ± 0.03	$1.62^{B} \pm 0.03$
Modified atmosphere	1.21 ± 0.03	1.46 ± 0.04	1.59 ± 0.04	1.73 ± 0.03	1.84 ± 0.02	$1.56^{A} \pm 0.03$
Overall mean (pooled over methods)	$1.21^{w} \pm 0.03$	$1.51^{x} \pm 0.03$	$1.58^{x} \pm 0.03$	$1.77^{y} \pm 0.03$	$1.87^{z} \pm 0.03$	–
Myofibrillar fragmentation index						
Aerobic	780.65 ± 10.70	763.78 ± 19.58	728.92 ± 9.85	699.84 ± 24.59	692.79 ± 11.82	$733.20^{AB} \pm 15.31$
Vacuum	780.65 ± 10.70	736.57 ± 6.24	713.58 ± 17.97	681.49 ± 17.11	673.04 ± 8.64	$717.07^{A} \pm 12.13$
Modified atmosphere	780.65 ± 10.70	767.78 ± 6.27	731.77 ± 8.41	712.53 ± 14.56	694.42 ± 9.53	$737.43^{B} \pm 9.90$
Overall mean (pooled over methods)	$780.65^{z} \pm 10.70$	$756.04^{z} \pm 10.70$	$724.75^{y} \pm 12.08$	$697.96^{xy} \pm 18.75$	$687.75^{x} \pm 10.00$	–

Overall means bearing different superscripts between rows ($^{A, B}$) and between columns ($^{w–z}$) differ significantly ($P < 0.05$ or $P < 0.01$). Interaction means bearing different superscripts ($^{a–g}$) differ significantly ($P < 0.01$).

- Buffalo meat packed in MAP had a desirable colour and a low drip loss.

- Buffalo meat packed under MAP and vacuum kept safely up to 14 days of storage at 4 ± 1 C.

MAP for fruits & vegetables



Mechanisms Softening of fruit structure

- Respiration rate can be reduced by decreasing O_2 concentration around the fresh produce

Effects on enzymes

- pectin esterase
- polygalacturonase
- polyphenoloxidase
- glycolic acid oxidase
- ascorbic acid oxidase

Effects on ethylene production

- blockage of the synthesis of ethylene which controls the activities of these enzymes

chilling injury of banana peel

O2: 12%
CO2: 4%

Thuy Nguyena et al., 2004

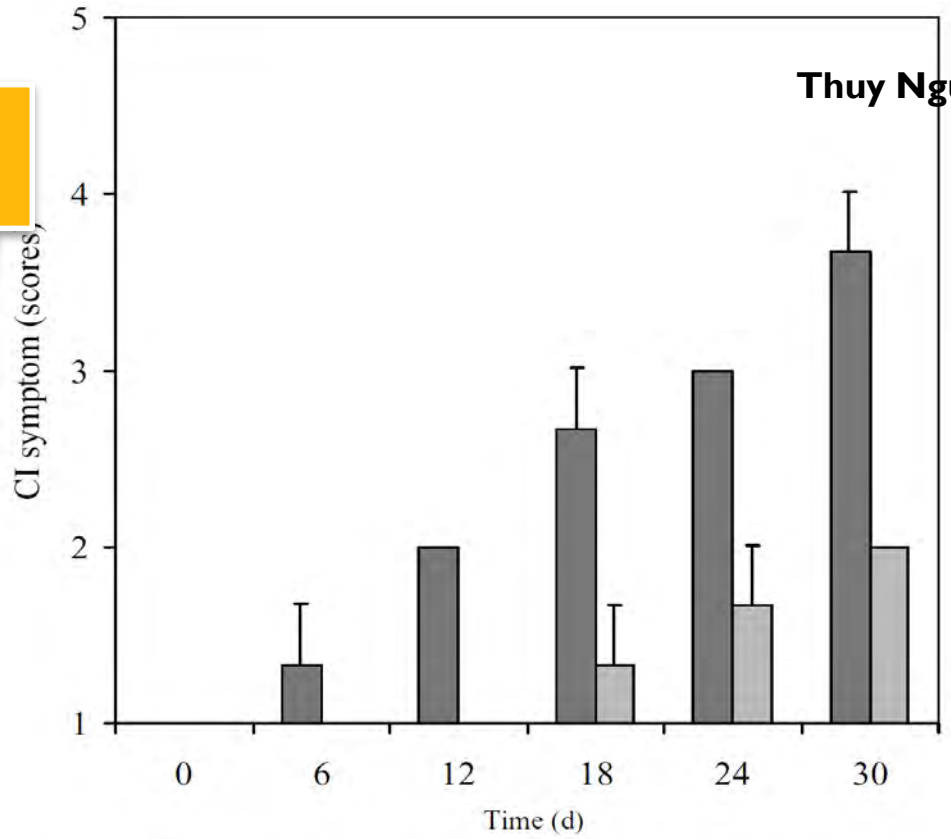


Fig. 1. Development of chilling injury of banana peel without (■) and with MA packaging (□) stored at 10 °C. Data are mean of the scores of three hands per MAP package or control box. The data of three MAP packages/controls were then averaged. Chilling injury was determined directly after storage, prior to shelf life. Vertical bars indicate S.D. When no bar is shown S.D. was zero.

Eating quality

Eating quality determined using a scale of 1–5 for each parameter

Parameters	Day 12			Day 18		
	Control	MA	Difference	Control	MA	Difference
Softness	2.43	4.00	–[a]	2.60	3.80	–[a]
Sweetness	3.21	4.14	–[a]	3.20	3.80	–[a]
Sourness	4.43	4.21	ns	3.40	4.20	–[a]
Flavour	3.21	4.21	–[a]	2.80	3.80	–[a]

A higher score indicates better quality. Bananas were stored at 10 °C for 12 or 18 days and then ripened at room temperature (28 °C) for four days. Scores were compared by the Wilcoxon rank-sum test.

[a] Indicates significant difference ($P < 0.01$) whereas ns means not significant.

Thuy Nguyena et al., 2004

Total phenols & enzyme activity

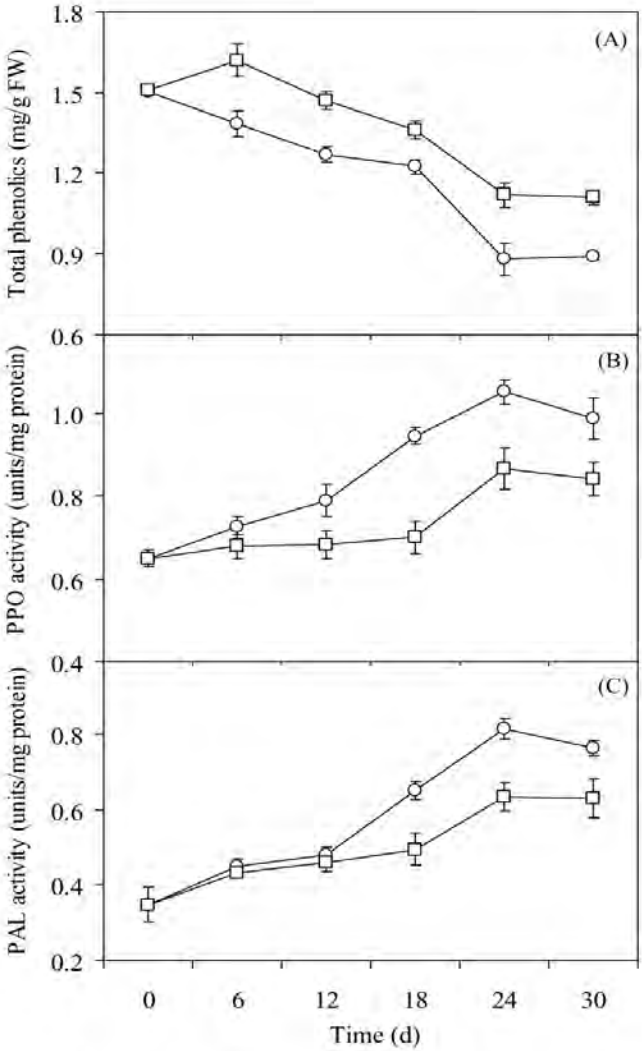


Fig. 2. Total phenolics (A) and the activity of PPO (B) and PAL (C) in the peel of bananas without (○) and with MA packaging (□) stored at 10 °C. Data are the means of three biological replications. The parameters were measured directly after storage, prior to shelf life. Vertical bars indicate S.D.

Thuy Nguyena et al., 2004

appearance

Fig. 3. Honeoye strawberries stored unpackaged (the 4 berries to the left) and packaged (the 4 berries to the right) for 7 days.

Nielsen et al., 2008

MAP for bakery products

Other application MAP/CAP

Pasta : CO_2 20%
N_2 70%
→ Storage life : 4 weeks

Pizza : CO_2 50%
N_2 50%
→ Storage life : 3 weeks

Sandwich : CO_2 80%
N_2 20%
→ Storage life : 3 weeks (+refrigeration)

VACUUM PACKAGING

VACUUM PACKAGING

Vacuum packaging is employed to achieved oxygen free atmosphere and to extend the refrigerated shelf life of:

- fresh meats
- processed meats

→ Vacuum packaging is also called SKIN PACKAGING

Product packed with vacuum packaging:

- Meat
- Poultry
- Processed food
- Fish
- Cheese
- Coffee
- Cut vegetables

Storage life: 2 -3 times
21 days at low temperature
6 months at freezing temperature

Packaging material used in vacuum packaging:

- Nylon – polyethylene laminate or
- aluminum foil

PE : - good heat seal property
- water resistant (low moisture transmission rate)

Nylon : - give strength
- barrier to O_2

Vacuum packaging will:

- Avoid evaporation
- Avoid weight loss
- Avoid dryness of product
- Avoid fat oxidation
- Avoid leaching of fluid and blood
- No need to treat the surface of product for trimming

Thank you for your attention!!