Agenda

- Industrialization, new trends and demands
- The product – composition and spoilage potential
- Microorganisms on food
- Why pack food
- Examples of optimal packaging conditions
- Modified atmosphere packaging
- Active packaging – oxygen absorber
- Active packaging - antimicrobials
- Recycling
- Alternative packaging materials
- Conclusion
Trends and demands

**Consumer**
- Safe
- Healthy
- Convenient
- Good tasting
- Diversity
- Low cost
- Organic / natural
- Environmentally friendly

**Food companies**
- Fewer and larger food companies
- Centralized production
- Larger scale
- Increased distribution
- Demands for longer shelf life
- Alternative preservation systems
- Competition for shelf space
- Catering
- E-commerce

**Authorities**
- Demands for documentation and traceability
- Legislation

**More Singles**
- Globalisation
- Oil prices
- Global heating
The package is an essential part of the preservation and quality ensureance of foods.

Quality = Microbiology + Chemistry + Structure

- Contaminants
- Gasses
- Water
- Shock
- Light

Convenience

Product

Product Information

Advertisement

Raw material / product

- Indicator
- Gasses
- Humidity
- Off flavour
- Migration
Ecological Determinants

**Environmental conditions and stress**

**Composition**
- (Intrinsic factors)
  - Water relations
  - Salts, sugars
  - pH
  - Preservatives
    - "Traditional" (spices, herbs, enzymes)
    - "Natural" (spices, herbs, enzymes)
  - Fat
  - Nutrients

**Microbial interaction**
- (Biotic factors)
  - Microbiota
  - Positive and negative interaction in food systems

**Processing**
- (Disturbance)
  - Heat treatment
  - Cleaning
  - Sanitation
  - High pressure
  - Non Thermal processing
  - Fumigation, smoke

**Storage conditions**
- (Extrinsic factors)
  - Temperature
  - Humidity
  - Gas composition (CAS, MAP)
  - Other gasses (CO, C₂H₄, ...)
  - Active packaging
  - Packaging material (Permeability, Bio-based)
  - Time

**Transport**

**Product**

**Packaging**
- Transport and storage
The interaction between pH and $A_w$ controls microbial growth in food-products
The different type of microorganisms

**Bacteria**
- Spreads on contact
- Spore formers are more resistant
- Growth demands (high humidity, neutral pH)
- Sensitive to drying out
- Forms biofilm

**Yeast**
- Spreads on contact
- Spore formers are more resistant
- Growth demands (medium-high humidity)
- Sensitive to drying out
- Forms biofilm

**Moulds**
- Mycelium
  - Are not spread, limited resistance
  - Sensitive to drying out
- Conidia
  - Hydrophobicity varies
  - Spread by air and dust

**Ascospore**
- Very resistant to heat and drying out

"Spores can be activated and start swelling and germination, when environmental conditions becomes favorable"
Food Ecology: All food products have their own specific group of microorganisms associate to them – The Microbiota

Spoilage

Fermentation
Successful packaging concepts

Milk stored in calf's stomach ⇒ Cheese

Olives in brine
Herring in brine
Grass or corn in piles

⇒ Fermentation - safe

Mummification (2.500 BC)

- Air tight
- Antimicrobial spices and herbs
- Resins (myrrh)
- Palm vine

Whisky maturation
How is packaging used in relation to food safety today?

Not safe foods
- Atmosphere control
  - Low or no $O_2$, high $CO_2$
  - High $O_2$, high $CO_2$
- Antimicrobial compounds (active packaging)
- Alternative to preservatives

All food types (safe or not)
- Protect from contamination (surroundings or packaging material)
- Tamber proff
- Protect from change in humidity (Dry out: OK)
- Chemical changes
- Temperature protection
- Indicator
Gasses used for MAP

Oxygen ($O_2$)
- preserves colour of meat
- Respiration/growth rate
- composition of flora

Nitrogen ($N_2$)
- no antimicrobial effect
- no colour effect
- insoluble, prevents collapse

Carbon dioxide ($CO_2$)
- antimicrobial effect
- composition of microbiota (flora)
Modified Atmosphere Packaging

**MA-packaging of read meats**
- 20 - 30% CO$_2$ and 80 - 70% O$_2$
- 0.5% CO, 70% CO$_2$ and no O$_2$

**Poultry**
- 25% CO$_2$, No O$_2$ or high O$_2$ %

**Cured meat products**
- O$_2$<0.5% and 20% CO$_2$, or vacuum

**MA-packaging of fish**
- White (low fat): 40% CO$_2$ and 30% O$_2$
- High fat: 60% CO$_2$ and 0% O$_2$

**MAP of fruit and vegetables**
- CO$_2$: 3 - 5%, O$_2$: 3 - 5%, Temperature: -1- 2°C, RH: >90%

**NB!** Tomatoes and banana > 10°C
Atmosphere induced changes in populations (chilled foods)

Air (high O\textsubscript{2}, low CO\textsubscript{2})
- Obligate aerobic psychrotrophic bacteria: *Pseudomonas*, *Acinetobacter*, *Psychrobacter*, *Shewanella*

Low O\textsubscript{2}, elevated CO\textsubscript{2}
- Microaerophilic bacteria: Lactics e.g. *Lactobacillus*, *Leuconostoc*, *Carnobacterium*, *Pediococcus*, *Brochothrix*
- Facultative anaerobic psychrotrophic bacteria: *Vibrio*, *Photobacterium phosphoreum* in fish, *Aeromonas* (Enterobacteriaceae)

No O\textsubscript{2}, high CO\textsubscript{2}
- Lactics
- Obligate anaerobes: Clostridia

N.B. Some aerobic and facultative anaerobic bacteria (e.g. *Shewanella* and *P. phosphoreum*) may use TMAO or NO\textsubscript{3} as terminal electron acceptors under anaerobic conditions.
Growth of *Listeria monocytogenes* on sausage at 10°C after CO$_2$ down-shift (air exposure)

©Susanne Knøchel, KVL, Denmark
Cheese types and their special packaging requirements

**Stabilized cheese**
- Creme cheese / processed cheese
- Decorated creme cheese
- Feta

**Active cheese**
- Semi soft and hard cheeses (whole sliced and shredded)

**Mold ripened cheese**
- White cheese (Brie / Camembert)
- Blue-veined cheese

- low O\(_2\), high CO\(_2\)
- low O\(_2\), CO\(_2\) control
- O\(_2\), CO\(_2\) control
Preservation of cheese

**Chemical**
- Sorbic acid (E200-3)
- Natamycin (E235)
- Imacilil

**Resistant strain**
- *Pencillium roqueforti / P. commune*
- *Pencillium discolor*

**MAP**
- Insufficient MAP
- MAP + high salt

**Resistant strain**
- *P. roqueforti, P. solitum, P. commune*
- *Debaromyces hansenii / Candida colliculosa*

**Heat processed**
- Chilled
- Ambient (20°C)

**Resistant strain**
- *Byssochlamys fulva / Paecilomyces variotii*
Trends and challenges in food packaging
Where are we going?

I’ve got it, too, Omar... a strange feeling like we’ve just been going in circles.
Modified atmosphere packaging

**FILM PERMEABILITY TOO HIGH**

- % oxygen / carbon dioxide

**FILM PERMEABILITY TOO LOW**

- % oxygen / carbon dioxide

**Optimal film permeability**

- % oxygen / carbon dioxide

**SHELF-LIFE**

- maincrop potatoes
- celery
- lettuces
- carrot
- leek
- soft fruit
- asparagus
- broccoli
- spinach
- bananas
- mushrooms

**RESPIRATION RATE**

- low
- high
Oxygen absorbers
Active packaging in use in Japan

Pictures taken November 2002
Use of WO sheets for box lunches

Box lunches for the volunteers at FIFA World Cup 2002

WasaOuro® from Mitsubishi-Kagaku Foods Corporation
Antimicrobial AP

Non volatile antimicrobials
- Chitosan
- Nisin, Natamycin, Sorbic acid, Benzoic acid, Lysozyme, Rosemary
- Ag-Zeolitter, Surface coatings

Volatile antimicrobials
- Essential oils (mustard, oregano, lemongrass, cinnamon, clove)

Edible active films (Chitosan, Casein, Gluten, Starch)
- Enzymes, antioxidants, antimicrobial compounds

Other types of active films
- Delivery of food colorants and aromas
- Delivery of vitamins and nutrients
- Adoption of aroma components / off flavours
Active packaging in the 21st Century
New active packaging concept on the marked

Temperature sensitive glue melts at high temp ⇒ controlled steam release

Enhanced Food Quality

♦ Retain flavours inside the package - only limited steam release

♦ Higher pressure ⇒ higher temperature ⇒ reduced cooking time

⇒ Reduced vitamin loss
⇒ Less colour change
⇒ Better texture

Enhanced Food Safety

⇒ More efficient heat kill of unwanted organisms
Price of crude oil is going up

CRUDE OIL PRICES
2004 DOLLARS

May 3: $72.29

Avg U.S. Price $18.59

Median U.S. & World Price $15.17

WTRG Economics ©2005
www.wtrg.com
(479) 293-4081
Transportation is getting cheaper by the building of larger vessels

COSCO Guangzhou 350 meters (1,150 feet) long and can carry a maximum of 9,500 TEU, i.e. 20" long containers (TEU = Twenty foot Equivalent Units).

Future:
- Suezmax: 400 meters long, 50 beam, 15 draught, 12000 TEU
- MalaccaMax: 470 meters long, 60 beam, 16 draught, 18000 TEU
Arguments for looking for alternative (Biobased) Packaging Materials?

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Disposal or recycling?
White/Industrial Biotechnology

Production of chemicals by biotechnology – the new S-curve in biotechnology

By 2010 20% of all chemical production will be by biotechnology (currently it is 5%)
Biobased materials
Fungal growth after 28 days at 30°C
Moisture loss from Danbo cheese packages relative to weight at time of packaging.
Oxygen concentration in the headspace of cheese stored in PLA and a conventional package.
Lipid oxidation

Hexanal concentration in cheese and yoghurt.
Conventional preservation systems are insufficient in some cases

Modified atmosphere packaging – spoilage of rye bread after 14 days

Suhr and Nielsen 2003 Journal of Applied Microbiology 94 (4), 665-674
Suhr and Nielsen 2005 Journal of Food Science 70:M37-44.
Biodegradable (EN13432): T>40ºC
High Water Vapor permeability
High Oxygen permeability

Biobased polymer: PLA

Cyclodextrin

Natural antimicrobials
Cinnamon
Clove
Mustard oil
Lemongrass

Fungi on Cheese
Debaromyces hansenii
Kluvariomyces marxinanus
Penicillium commune
P. casifulvum
P. camenberti
P. nalgiovense
P. roqueforti
P. verrucosum

Oregano
Orange
Sage
Thyme
Conclusions
New challenges – alternative strategies or business as usual?

- New products may require new preservation methods, also a benefit for “old” products.
- Single “hurdle” preservation is dangerous.
- Food microbiology and food matrixes are complex.
- Good knowledge of the food system may be needed.
- Different active packaging systems to different food types. Non volatiles need contact.
- AP may interact with food components (sensory changes).
- Natural antimicrobials may be natural toxins!