FF Instrumentation Ltd
Who are we?

food | dairy | grain | feed
Bob Olayo

Who am I

35 Year Old, married with 1 son.

Working with FF Instrumentation for >9 years

Currently Manager FF Instrumentation Ltd

Have been working with optimizing of MAP production for >6 years

Presented seminars at FTPT, to NZFSPG, FFDS MAP Seminars, Hastings, AKL, CHCH, AKL FIT and You”

Big experience with end users. (LIFE INC UNI)
Recent Developments in Packaging

- Skin Film
- Single Sticks
- Live Export
- The Retail Revolution
  - Supermarkets
  - Hypermarkets
  - Malls
New Technologies

- New technologies
  - High pressure microwaves
  - Oxygen absorption
  - Vacuum packaging
  - MAP
We haven’t invented anything NEW. MAP IS NOT NEW
We dont do anything new- just do it well.
What is MAP

Modified Atmosphere Packaging
What is MAP?

Removing atmospheric gases, to replace them with a more suitable mixture for the best preservation.
The History of MAP

- Storing ship biscuits in the eighteenth century
  - Lightning a candle in a barrel
- In the 1930s for transporting fruit in high CO$_2$
- In the 1950s and 1960s for transporting lamb from Australia and New Zealand
- Packaging bacon in England in the 1970s
  - They still do 😊
- The UK and Scandinavia have traditionally been trendsetters in MAP solutions – FFi has direct access.
- Later Equilibrium MAP was introduced (EMAP) MAP + Laser perforated foil for fruit and vegetables
Before you start MAP, Understand the Product

- The composition/type of the food defines the gas mix to be used

Parameters to consider
- Water activity
- Microbial activity
- Aerobic activity - bacteria that requires oxygen to grow
- Anaerobic - grows in the absence of oxygen
- pH values
- Cell respiration etc.
Methods and Machines

- Gasflushing
  Most used method
  Gas mixture is blown into the package to exchange the air and secure the desired level of residual Oxygen

- Compensated vacuum
  Air inside package is removed by using vacuum, and gas mixture is blown/sucked into the package to exchange the air.
  Very effective when it comes to concentrations of residual Oxygen
  But slow and with other limitations

- Passive modification
  Mostly used for live product
  A starting point for gas mixture is blown into the package to exchange the air and secure the desired concentrations.
  This will allow for necessary respiration to keep product fresh. Often used in combination with laser perforated film
Can MAP Help??

• To know if MAP can help, start by being very specific about what you want from the package.
• If “longer shelf life” is the goal, define shelf life.
  – Be specific about what defines end of shelf life (e.g. sensory, visual, micro, texture etc.)
  – These aspects will make it clear if MAP can help.
## MAP shelf life extension examples

<table>
<thead>
<tr>
<th>Product</th>
<th>Non MAP</th>
<th>In MAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw red meat</td>
<td>2-4 days</td>
<td>5-8 days</td>
</tr>
<tr>
<td>Raw Poultry &amp; game birds</td>
<td>4-7 days</td>
<td>10-21 days</td>
</tr>
<tr>
<td>Raw fish &amp; seafood</td>
<td>2-3 days</td>
<td>4-6 days</td>
</tr>
<tr>
<td>Fresh pasta</td>
<td>1-2 weeks</td>
<td>3-4 weeks</td>
</tr>
<tr>
<td>Fresh fruit &amp; vegetable</td>
<td>2-7 days</td>
<td>5-35 days</td>
</tr>
<tr>
<td>Bakery products</td>
<td>4-14 days</td>
<td>4-12 weeks</td>
</tr>
<tr>
<td>Dairy products</td>
<td>1-4 weeks</td>
<td>2-12 weeks</td>
</tr>
<tr>
<td>Cooked &amp; ready meals</td>
<td>1-3 weeks</td>
<td>3-7 weeks</td>
</tr>
<tr>
<td>Cooked poultry &amp; game birds</td>
<td>5-10 days</td>
<td>7-21 days</td>
</tr>
<tr>
<td>Cooked fish &amp; seafood</td>
<td>5-10 days</td>
<td>7-21 days</td>
</tr>
<tr>
<td>Cooked vegetable</td>
<td>3-14 days</td>
<td>7-21 days</td>
</tr>
<tr>
<td>Dried food products</td>
<td>4-8 months</td>
<td>1-2 years</td>
</tr>
</tbody>
</table>
• MAP GASES
To understand the different MAP gases, it is important to focus on their characteristics:

Consider their:

- Solubility
- Influence on the food
  - Odour
  - Taste
  - Colour

**Handling**
- Storage, different tank sizes
- Premix or with mixing panel
MAP Gases

GASES

CO₂

N₂

O₂

CO
Before alllllllll that!!

• AIR

20.9% Oxygen
### Examples of gas mix ratios

<table>
<thead>
<tr>
<th></th>
<th>Bulk</th>
<th>Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw Red Meat</strong></td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Raw Offal</strong></td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Raw Poultry &amp; Game Birds</strong></td>
<td><img src="image5" alt="Graph" /></td>
<td><img src="image6" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Poultry, Dark Portions &amp; Cuts</strong></td>
<td><img src="image7" alt="Graph" /></td>
<td><img src="image8" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Raw Fish (Low Fat)</strong></td>
<td><img src="image9" alt="Graph" /></td>
<td><img src="image10" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Raw Fish (High Fat)</strong></td>
<td><img src="image11" alt="Graph" /></td>
<td><img src="image12" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Crustaceans &amp; Molluscs</strong></td>
<td><img src="image13" alt="Graph" /></td>
<td><img src="image14" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Cooked &amp; Cured Meat</strong></td>
<td><img src="image15" alt="Graph" /></td>
<td><img src="image16" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Cooked, Cured Fish &amp; Seafood</strong></td>
<td><img src="image17" alt="Graph" /></td>
<td><img src="image18" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Cooked, Cured Poultry &amp; Game</strong></td>
<td><img src="image19" alt="Graph" /></td>
<td><img src="image20" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Cook- Chill &amp; Ready Meals</strong></td>
<td><img src="image21" alt="Graph" /></td>
<td><img src="image22" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Combination Products</strong></td>
<td><img src="image23" alt="Graph" /></td>
<td><img src="image24" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Fresh Pasta Products</strong></td>
<td><img src="image25" alt="Graph" /></td>
<td><img src="image26" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Bakery Products</strong></td>
<td><img src="image27" alt="Graph" /></td>
<td><img src="image28" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Hard Cheese</strong></td>
<td><img src="image29" alt="Graph" /></td>
<td><img src="image30" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Grated &amp; Soft Cheese</strong></td>
<td><img src="image31" alt="Graph" /></td>
<td><img src="image32" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Dried Food Products</strong></td>
<td><img src="image33" alt="Graph" /></td>
<td><img src="image34" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Cooked Vegetables</strong></td>
<td><img src="image35" alt="Graph" /></td>
<td><img src="image36" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Liquid Food &amp; Beverages</strong></td>
<td><img src="image37" alt="Graph" /></td>
<td><img src="image38" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Carbonated Soft Drinks</strong></td>
<td><img src="image39" alt="Graph" /></td>
<td><img src="image40" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Fresh Fruit &amp; Vegetables</strong></td>
<td><img src="image41" alt="Graph" /></td>
<td><img src="image42" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Gas Mix Ratios:**
- **Oxygen (O₂)**
- **Carbon Dioxide (CO₂)**
- **Nitrogen (N₂)**
Explanation of each gas

The Different MAP Gases

• Carbon Dioxide – CO₂
  – Inhibits microbial activity as it lowers PH level
  – However!! - anaerobic microorganisms are less affected
  – Excess levels of CO₂ can cause flavour tainting
  – CO₂ is highly dissolvable and can cause drip loss and package collapse (Snug down)
  – CO₂ is absorbed in the liquid face of the product (Water, fat etc.)
Carbon Dioxide

CO₂ is stored in cold environments (-15 to -10°C) This may cause tubes to freeze which leads to

- Pressure drops in the tank
- Customer spending too much CO₂
- Difficulty reaching the right Oxygen level

Therefore

- Mount a gas heater –
- This will allow you to more easily reach the low O₂ level desired
- Save gas
- Better Snug down when using pure CO₂
Nitrogen

- Nitrogen - N\(_2\)
  - Primarily used to replace oxygen preventing oxidation
  - Promotes a "pillow effect" when used with CO2
  - Less or no effect on microorganisms
  - *Does not dissolve*, hereby maintaining package volume
  - Cheap gas compared to other gasses
  - Can be delivered via a Nitrogen generator
Oxidation Example

Sample X

Gas Level (%)

Months Equivalent

Sample X

Peroxide Value (mEq/kg)

Months Equivalent
Nitrogen Generators

• If choosing or setting up- CAUTION!
  – Make sure the generator gives the right purity
    If a generator provides 99.5 % pure N₂
    Then it is impossible to have below 0.5% Oxygen
  – Gives a lower pressure than bottled gas. **you either need a pressure booster, or use a MAP Mix Provectus
  – However, this solution can be a stable and cheaper gas supply
Oxygen

- Oxygen - \( \text{O}_2 \)
  - Normally perceived as least desirable in most applications (hence “RO” meters)
  - Allows growth of aerobic microorganisms
  - Preserves the oxygenated myoglobin which gives meat its red colour
  - For breathing food and vegetables some oxygen is essential to allow respiration, hereby maintaining freshness
  - However NOTE - Minced meat will become grey when cooked. Makes it hard to see if it is well done or not. The meat can have a taste like it is precooked
Carbon Monoxide

- Used for red meat, because of its ability to preserve the red colour
- Not recognised in the European Union and its use is forbidden by law
- Still used in other regions of the world, such as North and South America
- In the USA 0.4% of CO is considered GRAS (Generally Recognised As Safe, 2002), but only for use in bulks packages
- In 2004 the FDA allowed the use of 0.4% CO for use in retails packages
- CO preserves the red colour in meat even after the meat has gone “bad”
Carbon monoxide (CO) interacts with myoglobin to form a stable, bright red colour but this reaction prevents meat from browning naturally with age so it is difficult to tell how fresh the meat is (Brooks, 2008). For this reason, the use of CO for meats stored under MAP is banned in the European Union, but is still permitted in the United States and is used in small concentrations (<1%) for some New Zealand meats.

The Food Standards Code (FSC) has specific provisions relating to the use of carbon monoxide in fish. Because of this the guide can be quite specific.

For meat the FSC allows the use of carbon monoxide as a processing aid. There are no specific limits listed. See Standard 1.3.3 – 4 and Schedule 18.2 of the FSC. It is very unlikely that MPI will issue more specific guidance for meat.
Formula Foods Shelf Life

Revolutionary “complete picture”

- Run both realtime and accelerated.

- Have been performing shelf life testing in NZ for over 20 years. Trusted by AU supermarket chains.

- Track aW, Texture, MAP, Sensory, colour, light exposure, micro, viscosity etc.
How to Determine the Shelf Life of Food

A Guidance Document

22 July 2014

New Zealand Government
Product Specific Map

Fresh pork
• Main decay is loss of colour (turns brown)
• Packaged in 70-80% oxygen (supermarket)
• Hi O2 preserves the red color caused by the oxymyoglobin
• Often in combination with 20-30% CO₂
• Refrigeration is essential
• Often a moisture absorber is included (drip)
• Often packed on tray sealing machines as this will present the product best
Recent study
Danish Meat Research Institute

- Packing Pork Chops & Schnitzels in 40% O₂ / 20% CO₂ / 40 N₂ – Gives a more juicy and tender meat, with a less rancid flavour
- Sliced Pork belly or minced pork in 50% O₂ / 40% O₂ / 10 N₂ – results in a more crispy texture and less bitter taste
- 3-gas mixture seems to have the same shelf life, and a better eating quality.
- More than 50% of a gas seems to harm the product
- NOTE: Cut specific
In raw sausage there may be spices, nitrites etc. in the recipe.
As they aren’t pre-cooked, they are highly affected by O2 and light.
Best way to achieve better shelf life without browning is test with 80%O2/20% CO2 to keep the red color - - Or test how much light there is in the store to determine best packaging material
Remember, if you have e.g. 2.000 Lux on top of the cooler, the product will more easily go brown / grey.
Greying may be reduced by maintaining a residual O2 below 0.3%
Product specific MAP

Cold meats
Sliced products
Salami
Product specific MAP- Cold Meats

- Main decay is rancidity, moulds, green colour and microbial growth
- A very low concentration of residual oxygen required, preferably below 0.5%
- Anywhere from 10-50% of CO$_2$ is used to inhibit microbial activity
- Refrigeration is of essential
- Packed on all kind of machines
Recent study
Danish Meat Research Institute

- With different kinds of meat products, it is well known that CO$_2$ has a good effect on slowing down bacterial growth
- It is also known that "Snug down" can be a problem if CO$_2$ is high
- Soluble gas saturation (CO$_2$)
  - Saturate the meat with CO$_2$ before packing
  - No collapse of the pack (Snug down)
Recent study
Danish Meat Research Institute

- Light, temperature & O₂ affects the meat
  - rancid taste & grey color
  - 0.1 % O₂ and darkness gives the best shelf life
  - 2% O₂ & 600 Lux has a huge impact
  - 2% O₂ & 1.200 Lux has 200 times the impact

• Color stable cooked meat
  - Above 0.1% O₂ affects the color
  - Commercial test shows
    92% of all packs are over 0.1 % O₂
    65% of all packs are over 0.5% O₂
LAMB
Case Study

Barkers of Geraldine, Canterbury, New Zealand
Problem
Thoughts??
Process

• Hot filled product made the old fashioned way no preservatives and has real fruit.
• Flushed with 100% CO2
• Did not measure residual oxygen.
Their ideas of the cause

- Vacuum
- Temperature
- Plastic material
- Oxygen uptake by the products

At the time approached were going to trash $65,000 worth of packing material as that was the suspected “main” Cause.
Finding the solution

• Loaned MapMix Provectus and Checkpoint
• Visited plant to run trials and advised on N2/CO2 mixes.
• Client monitored the different batches
• After 1 week they sent me an email with the following photo and statement.
“the photo tells the whole story”

Richard George
Process Development Manager
Barker Fruit Processors Ltd
Result
Product specific MAP

Poultry and Game
Product specific MAP – Poultry and Game

High level of hygiene is **VERY** important – bad in bad out

- Most known reason for decay is microbial growth (Pseudomonas, Achromabacter).
- Packed in more than 20% CO$_2$ to reduce campylobactor.
- Mostly packed on tray sealing machines as this will present the product best.
- Lately the whole bird is packed on a flowwrapper.
- Tricky???????? Cavity residual O2
- Big differences in Gas blend, depending on country, tradition and ”Skin on/Skin off”
- Some countries use high O$_2$ to keep the color. Other places 70% N$_2$/30% CO$_2$ for longer shelf life.
- 20% CO$_2$/ 80% O$_2$ or 30% CO$_2$/ 20% O$_2$/ 50% N$_2$ can be used in some cases to maintain the color.
Product specific MAP

Seafood
Main decay is a result of microbial and oxidation activities

The high water activity is also a determining factor

Neutral pH and autolytic enzymes will rapidly cause undesired odours

The presence of CO$_2$ is essential to inhibit growth of normal aerobic bacteria

Recommended gas mixtures are:
CO$_2$: 35-45%, O$_2$:25-35%, N$_2$:25-35%
Product specific MAP

- Most important gas is CO$_2$, but collapsed packs and sour fish can be the result
- Hygiene and temperature are the most important factors
- Low temperature gives better result with warm water fish.
- Read more on www.difresh.com
MAP - Modified Atmosphere Packaging

Product specific MAP

Fresh pasta
Product specific MAP – Fresh Pasta

• Easily exposed to microbial attacks
• Low concentration of residual oxygen is required, preferably well below 1%
• High concentration of CO$_2$ is used to block the growth of possible microorganisms and molds
• Principal spoilage is Yeasts and moulds, colour change (green to brown/grey) for green pasta.
• Refrigeration is essential
• Light Exclusion preferable (green)
• Packed on all kind of machines
Product specific MAP

Bakery products
Product specific MAP

- A very low concentration of residual oxygen is required, preferably below 1%
- Humidity is a main concern
- Correct permeability features are essential
- Principal spoilage mechanisms for non-dairy bakery products are mould growth, staling, and moisture migration.
- High concentration of CO₂ is used to inhibit bacterial growth, from 60-80%
MAP - Modified Atmosphere Packaging
Product specific MAP

- The high CO\textsubscript{2} concentration also slows down the staling process
- High moisture in the bakery product (more than 8\%) can give problems with mold
- High level of hygiene recommended
- Actual example
- Different recipes require different gas mixtures
- Can be sprayed with alcohol as preservative
  - Does not work with Zr sensor (cross sensitive-covered later)
What solution does Dansensor have for Human Blood??

= $O_2$
Human Blood Project

O2

CO2

N2

MIXING

“Heart and Lung Machine”

<6 L/M
0.2 O2 – 80% O2
Success
Product specific MAP

Dairy products

Cheese
Product specific MAP

- A low concentration of residual oxygen is required, preferrably below 0,5%
- Packing Scredded or sliced cheese in a mix of N₂ and CO₂ to avoid ”Snug down” collapsed packes
- Bacteria, moulds & fungus are main issues
- It is often a problem to get the right O₂ level (Grated)
• EXCEPTIONS
• Blue cheese which needs oxygen to keep their typical molds alive.
• Main decay reasons are Bacteria, molds and fungus.
• High concentration of CO$_2$ is used to avoid the growth of bacteria.
Choice of gas mixture will vary depending on the composition of the cheese.

The cheese will absorb the CO$_2$ causing the package to "snug down" almost appearing as vacuum packed – Pure CO$_2$ is NOT a good idea when packing sliced or shredded cheese due to "snug down".

Even low concentrations of O$_2$ can cause growth of mould.

However
Product specific MAP

Diary products
Milk powder
MAP - Modified Atmosphere Packaging

Product specific MAP

- Milk powder often packed in 70% N₂ & 30% CO₂
- Either packed in Cans, bags or sachets
- Cans especially have a long shelf life
- Because of the expensive cans, “non destructive” leak test are important
- “Overseas government” getting pedantic after “pipe”
Product specific MAP

Fruit and vegetables
Main thing to consider is to allow for respiration

Accordingly, you need some oxygen anywhere from 2-10% depending on product

In general the faster the growth in nature the higher concentration of oxygen you need

High humidity can cause more rapid decay

Finding the balance in respiration with the correct gas mixture is essential
Product specific MAP – Fresh Fruits and Veges

- Respiration will consume oxygen and generate ethylene and CO$_2$
- Some producers use laser perforated packaging material (E-MAP)
- CO$_2$ concentration will vary from 2-20%
What is EMAP

Laser perforation

• EMAP is when you try to keep the same level of O₂ and CO₂ in the package by making laser perforated holes in the foil.
• As an example 2 – 3 holes, 25 micron E.g. 5% O₂ & 5% CO₂ Varies from product to product
• Test shows that you can have a huge improvement on shelf life
• Packing whole fruit & vegetables is very different to Sliced or shredded.
Packing vegetables

- Keep the vegetables alive
- Have a uniform MAP level and increase the shelf life with up to 3 weeks
Any Questions

Break????
WHAT IS A LEAK?
WILL IT AFFECT YOUR PRODUCT?

Holes in a package (Ex. 40 µ) will have huge impact on the Shelf Life of a product.

These holes can be hard to find. Just like a dollar on a football pitch

Do you think the spectators can find the dollar?
What is a Leak?
Will it affect your product?

- A human hair is 80 - 100 µ
- A 40 µ hole can have 10 bacteria side by side
- A package with pure N₂ and a 100 µ hole will contain 7.5% O₂ after 24 hours. (Atm. Pressure)
- Food industry expects that 1-3 % of all packages are leaking.
- Independent institutes have calculated that the problem is closer to 40 %

DRMI & Lincoln University
Tesco UK asked Lincoln Universit, UK to do a survey about leaking packages since Tesco believes that Leaks are a big problem.

Food Industry believes that they have 1% leakers.

Most of the factories uses Squeeze test.

The students took a lot of “accepted” packages just before they are packed in cardboard boxes.

Cut the packages open with a knife and removes the product. Used blue ink to test for leaks.
WRAP survey - UK

How?

- **Survey was done like this;**
- 6 different companies represented
- 11 factories
- 105 packaging machines - Flow pack, Tray sealing and Thermoforming
- **Following industries**
- Meat, Poultry and vegetables
- Frozen (11%), chilled (59%) and produced in room temperature
- Production around 500,000 packs per site per day
WRAP Study in UK
Interesting answers

- Producers expected 1% Leak rate
- Actual Leak rate 24%
- It is estimated that 480,000 tons of food are discharged in UK due to leaking packs
- Most common reason for Leaks are contamination of the welding area
- Big difference between reality and expectations
How does Leaktest work?

- Put the package into the champer (Close lid)
- The Leaktester makes a vacuum
- If there is a leak, the sensor will notice CO₂
- The tester will tell you there is a Leak. All tests will be collected, and can be transferred
- If no Leak – You can sell your product
How does Leaktest work?

**CO₂ as a trace gas**

- We recommend to minimize the champer size as much as possible.
- Minimum 5% of CO₂.
- Delta Pressure – Minimum 100 mBar.
- A lot of CO₂ in the production area is not good for you.
LeakPointer & LeakMatic
A few different solutions
Thank You
Any Questions