Mana Kai Rangahau

New Zealand Institute for Crop & Food Research Ltd.

Modified Atmosphere Packaging of Seafood

Graham C Fletcher

Mana Kai Rangahau

Overview

- Background
- Our research on hoki
- Critical parameters for success
- Our research on salmon
- Future research plans
- Conclusions

Mana Kai Rangahau

New Zealand Institute for Crop & Food Research Ltd.

Background

What is MAP?

Seafood applications.

How does it work?

Safety considerations.

Modified/Controlled Atmosphere Packaging (MAP/CAP)

- Place product in a gas impermeable container (e.g. a flexible film or a shipping container)
- Remove air surrounding the product.
- Replace with a chosen gas mixture:
  - usually carbon dioxide and nitrogen
  - sometimes oxygen, argon, carbon monoxide etc.
- Seal the product and gas mix in the container.
  - MAP: allow changes to occur after packing
  - CAP: actively maintain the gas mix as originally packed

Mana Kai Rangahau

Modified Atmosphere Packaging

Mana Kai Rangahau

History

- Commonly used for seafood in Northern Europe, particularly France and the UK
  - In the 4 years to 1990 sales of MAP packages in Europe increased 5-fold to 250 million
  - 1995, 400 million packages sold in the UK
  - May have declined since then
- Starting to appear on Australian supermarket shelves - Simplot
- Not applied commercially for seafood in NZ
- Virtually unused in USA
  - Restricted due to safety concerns
  - “secondary measures in addition to refrigeration must be employed to increase assurance of product safety” – NACMCF, 1992

CROP & FOOD RESEARCH
Mana Kai Rangahau

Why use MAP?

- Changing the gas environment slows bacterial growth and enhances shelf-life
- Retail packs:
  - Attractive, product visible
  - Robust, leak proof, odourless, easy to label, convenient
  - Producer has control of product form and marketing

- Draw backs
  - Bulky, difficult to chill, increased cost
  - Safety concerns – anaerobic environment may allow growth of pathogens before spoilage

Shelf lives claimed

Mana Kai Rangahau

Species	Temp (°C)	Gas	MAP shelflife	Extension (cf air)
White fish	5	$CO_2/N_2/O_2$	9	1.5x
Whiting	26	CO_2	2	1x
Whiting	4	CO_2	15	2x
Rockfish	1.7	CO_2/Air	13	2.2x
Rock cod	4	CO_2/Air	21	3x
Mackerel	0	CO_2/N_2	6.5	1.9x
Trout	1.7	CO_2/Air	20	1.7x
Scallops	4	CO_2	22	1.8x
Shrimp	4	CO_2	15	3x
Scampi	0	$CO_2/N_2/O_2$	4.5	1.5x
Crab	1.7	CO_2/Air	25	1.8x
Crayfish	4	CO_2/Air	21	3x

From Farber et al. (1991) and Church et al. (1998)

Pack formats

Mana Kai Rangahau

- Retail pack
- Master pack
  - Permiable overwrap packs placed in larger imperiable master pouches and flushed with CO_2
  - Removed from master pack before retail
- Bulk transport
  - Specially constructed refrigerated container loaded with pre-cooled product and gas mix injected
  - E.g. 1979 2.3M lb salmon in USA

Effect of gases on seafood

CROP & FOOD RESEARCH
Mana Kai Rangahau

- **Carbon dioxide (CO_2) inhibits growth of many spoilage organisms**
- **Excluding oxygen (O_2)**
  - **inhibits oxidation**
  - **Inhibits growth of aerobic bacteria**
  - **May maintain colour**
- **Nitrogen (N_2) acts as an inert filler**
- **Argon (Ar) is heavier than N_2 and has been claimed to be better at displacing oxygen**
- **Carbon monoxide (CO) maintains red colours**
  - **accepted in USA but not Europe or FZANZ**

Safety: *Clostridium botulinum* type E

CROP & FOOD RESEARCH
Mana Kai Rangahau

- **Produces a potent neurotoxin**
- **Toxin destroyed with cooking (5 min, 60°C)**
- **Organism occurs naturally in marine environments**
- **Toxic organism not known in Australasia**
- **Will not grow below 2.9°C**

- **US requires controls additional to refrigeration (e.g. use-by-date of <10 days from packing or indicators)**
- **UK code of practice allows unlimited distribution life where monitored temperatures are below 3°C but no more than 10 days of refrigerated shelf life once out of monitored control**

Safety – *Listeria monocytogenes*

CROP & FOOD RESEARCH
Mana Kai Rangahau

Listeria monocytogenes

- **Not naturally a part of wild caught seafood microflora**
- **Limited sensitivity to CO_2 or absence of O_2**
  - **Growth slowed but not eliminated**
- **Will grow down to –1.5°C**
- **Eliminated by adequate cooking**
- **Otherwise control must be at source or by shelf-life limitations**

Mana Kai Rangahau

New Zealand Institute for Crop & Food Research Ltd.

Modified Atmosphere Packaging Research on Hoki

Applicability to our largest fish resource

CROP & FOOD RESEARCH

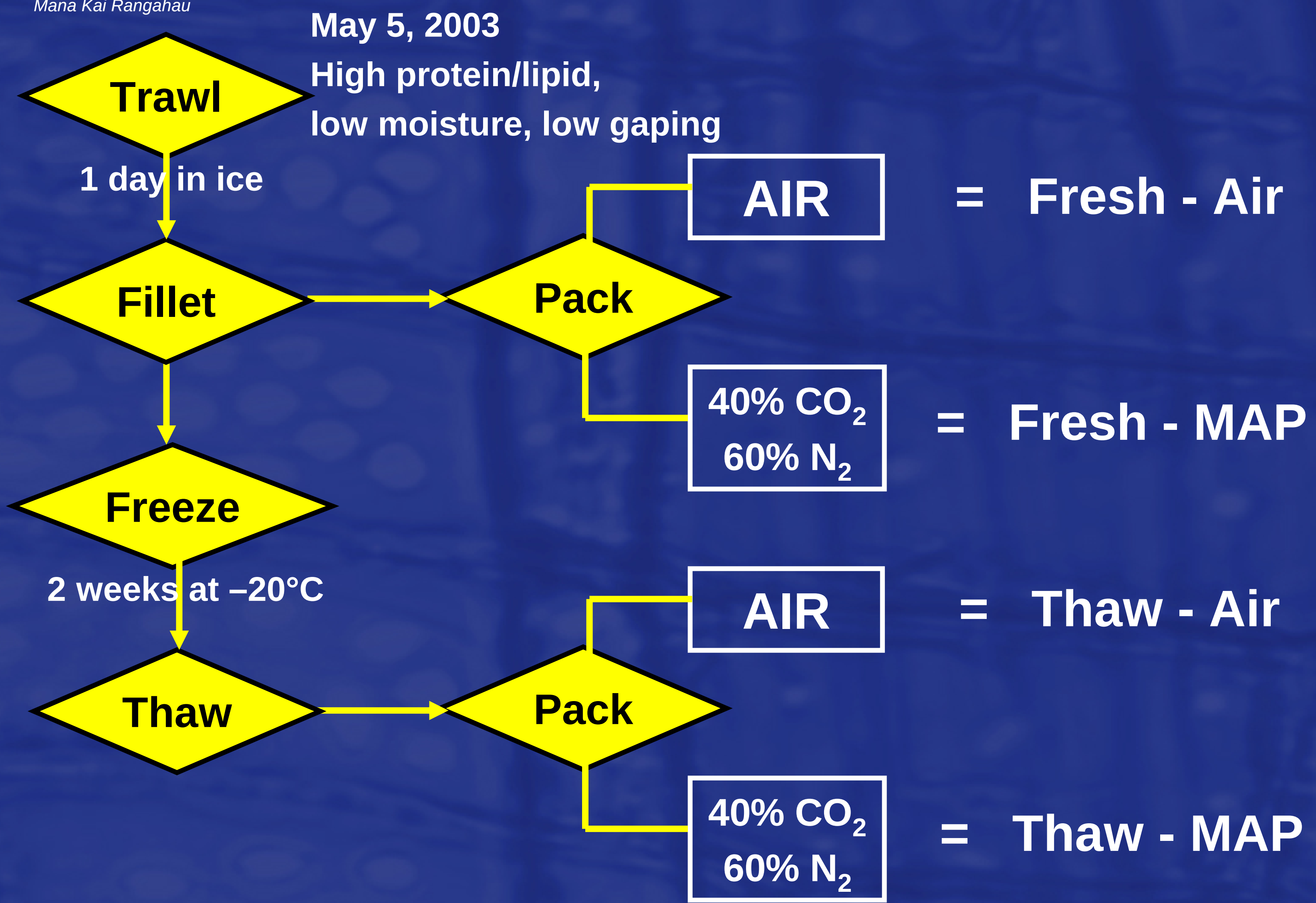
Mana Kai Rangahau

Aims

- Determine whether and to what extend MAP can increase the shelf life of hoki fillets
- Compare the quality and shelf-life of MAP hoki prepared from fresh and thawed fillets
- Consider the effect of seasonal variation on the shelf life of MAP hoki

Experimental treatments

Mana Kai Rangahau



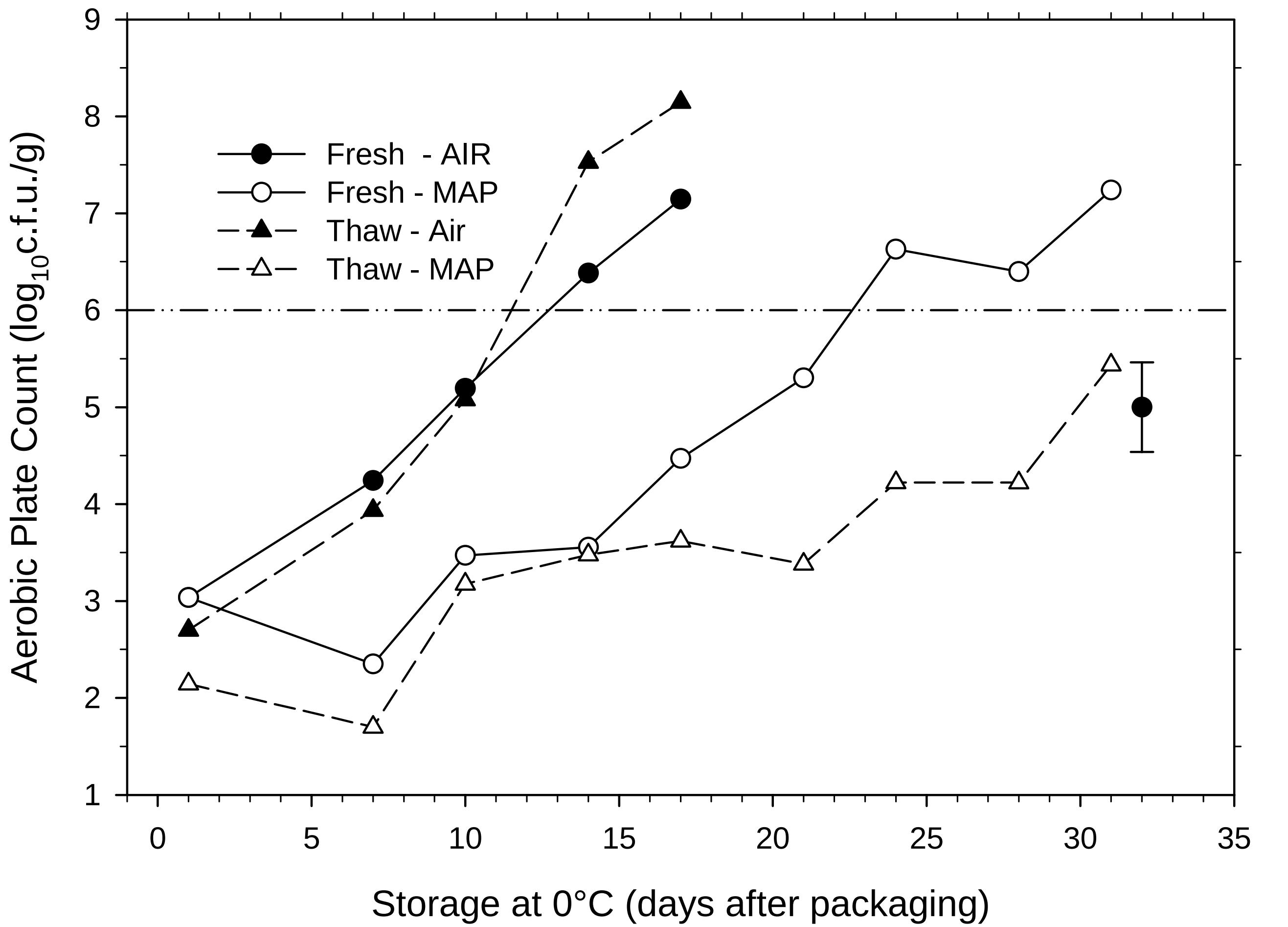
CROP & FOOD RESEARCH
Mana Kai Rangahau

Sampling and analyses

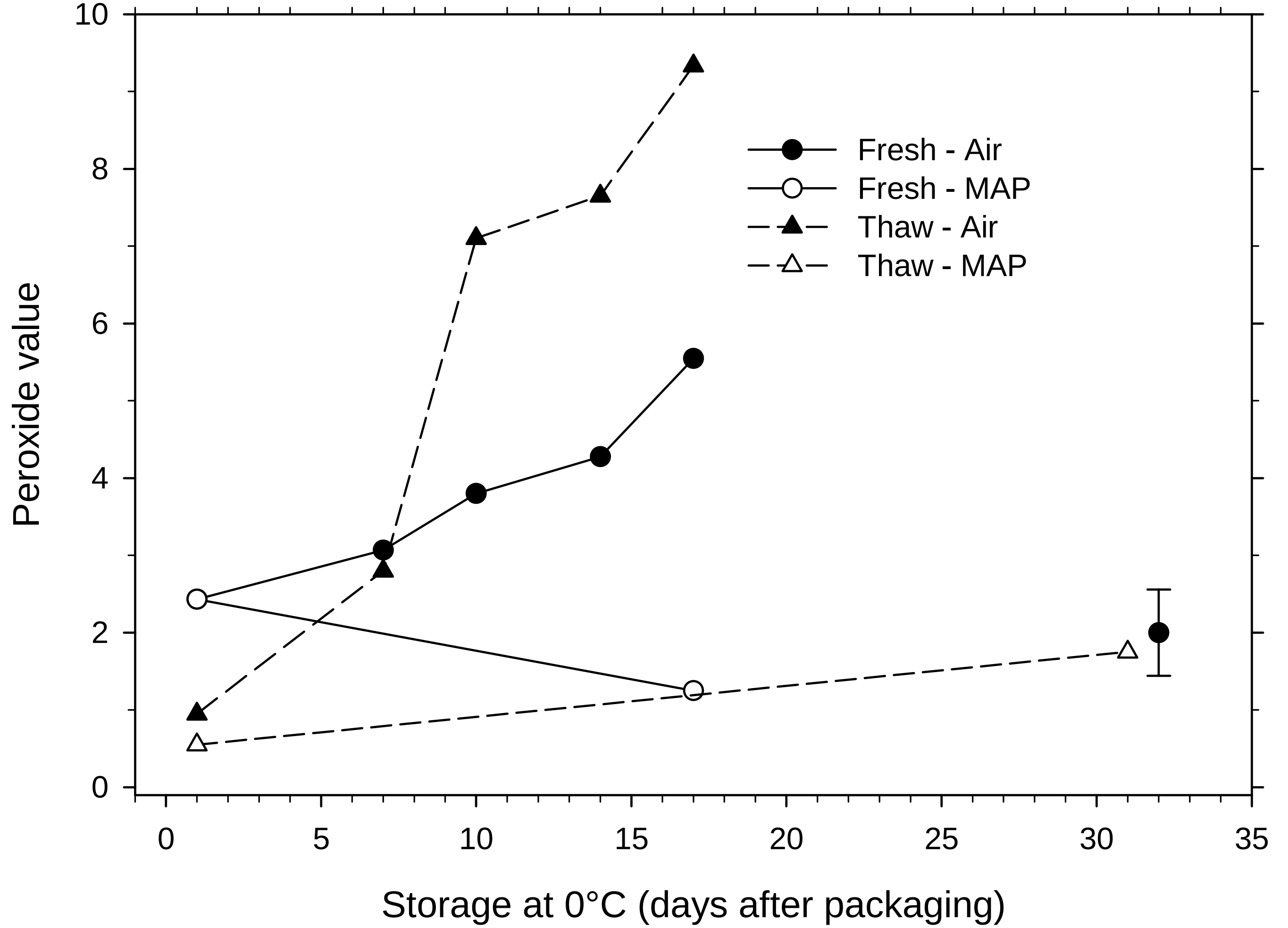
- **Packs were stored at 0 ± 0.05°C**
- **Air packs were sampled after 1, 7, 10, 14, 17 days at 0°C**
- **MAP packs were sampled after 1, 7, 10, 14, 17, 21, 24, 28 and 31 days at 0°C**
- **On each occasion 4 packs were sampled for physical, chemical and microbiological evaluation and 8 packs for cooked sensory evaluation**
- **Analyses included O_2, CO_2, APC, sulphide producing bacteria, CO_2-resistant bacteria, microflora composition, raw sensory, gaping score, colour, Torry freshness meter score, pH, E_H, drip loss, instrumental textural analyses, ATP catabolites, TVBN, TBARS, and peroxide values.**
- **A trained panel (10) each tasted cooked fish from each treatment twice on each occasion, scoring 29 attributes on 6 point intensity scales.**

Results

Bacterial counts – APC (20°C)

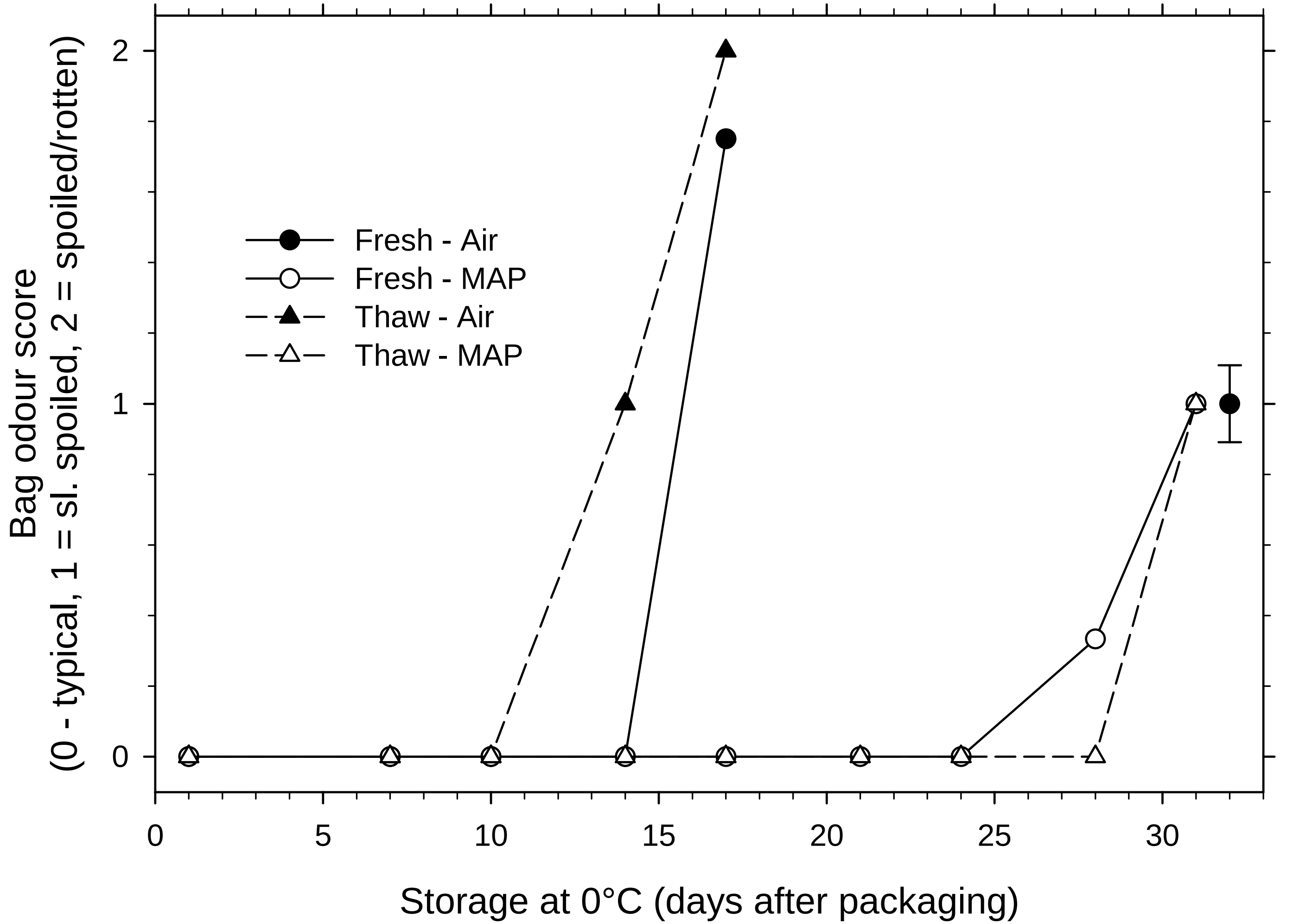


Oxidation – peroxide value



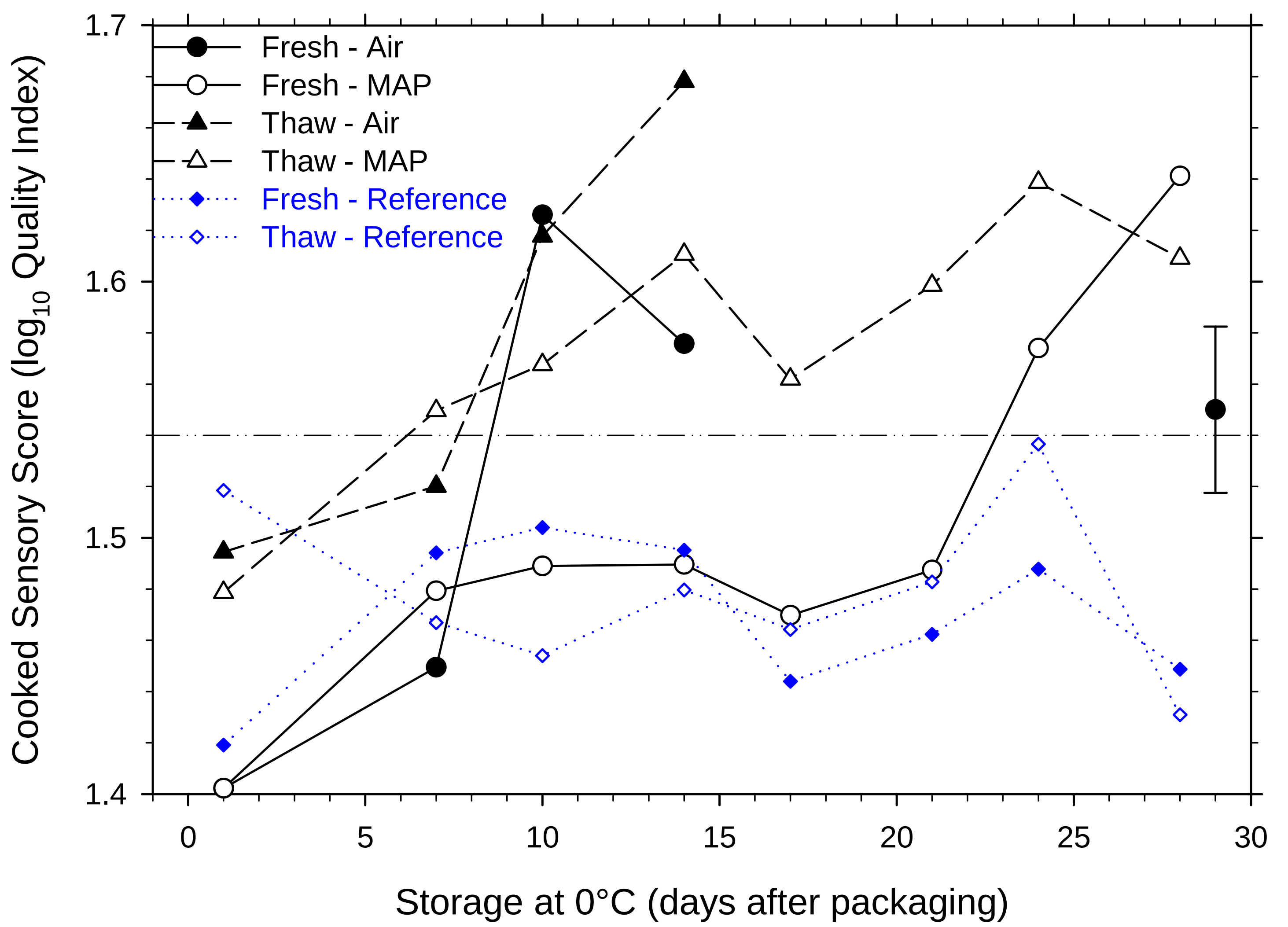
CROP & FOOD RESEARCH
Mana Kai Rangahau

Raw odour



Mana Kai Rangahau

Cooked sensory evaluation



Critical success parameters

Mana Kai Rangahau

- Acceptability of MAP in selected market
- Temperature (-1.5°C to +3°C)
  - Fish will spoil twice as fast at 4° than at 0°C
  - Dropping temperature from 2° to 0°C will give a 1.4x shelf life extension
- Raw material quality must be high
  - MAP will not prevent spoilage of marginal quality product (APC <10^4/g)
- Choice of film – must have high O_2 barrier, other characteristics?
- Access of gas to the product
- Choice of gas mix – optimised to suit the product
- Fish:Gas ratio

Mana Kai Rangahau

New Zealand Institute for Crop & Food Research Ltd.

Modified Atmosphere Packaging Research on Salmon

Optimising gas mixes and fish to gas ratios

Mana Kai Rangahau

Gas composition – research

- Most published research to date empirical
- Results cannot be applied beyond experimental conditions
- Often focused on one aspect of shelf-life
  - Microbial growth
  - Sensory

Mana Kai Rangahau

MAP Salmon Results

- CO_2 is the main anti-microbial agent in MAP
- A key parameter is the amount of CO_2 available to act on the fish flesh.
- Increasing CO_2:
  - Will reduce bacterial counts
  - May induce unacceptable sensory characteristics
- We determined the effect of increasing amounts of CO_2 on salmon

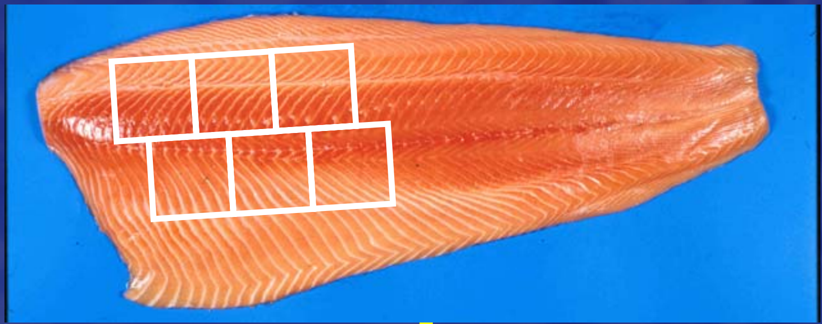
MAP - Seafood

Our Approach

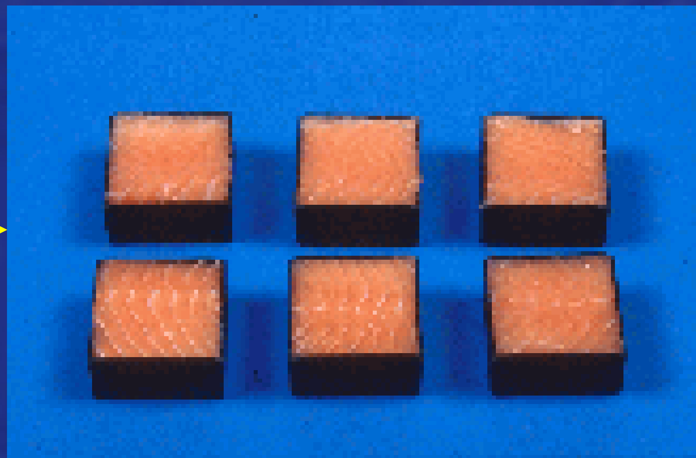
- Develop a model that can be used to answer 'What if?' questions
- Salmon as an initial model species because we had control of the starting material

CROP & FOOD RESEARCH
Mana Kai Rangahau

MAP Seafood
Our Method



- Use fish pieces from chosen positions of fixed size and exposed surface area



CROP & FOOD RESEARCH

Mana Kai Rangahau

MAP Seafood

Our method

- Deliver known volumes of gas (by GC syringe)
- Store in melting ice (0 ± 0.05°C)

Mana Kai Rangahau

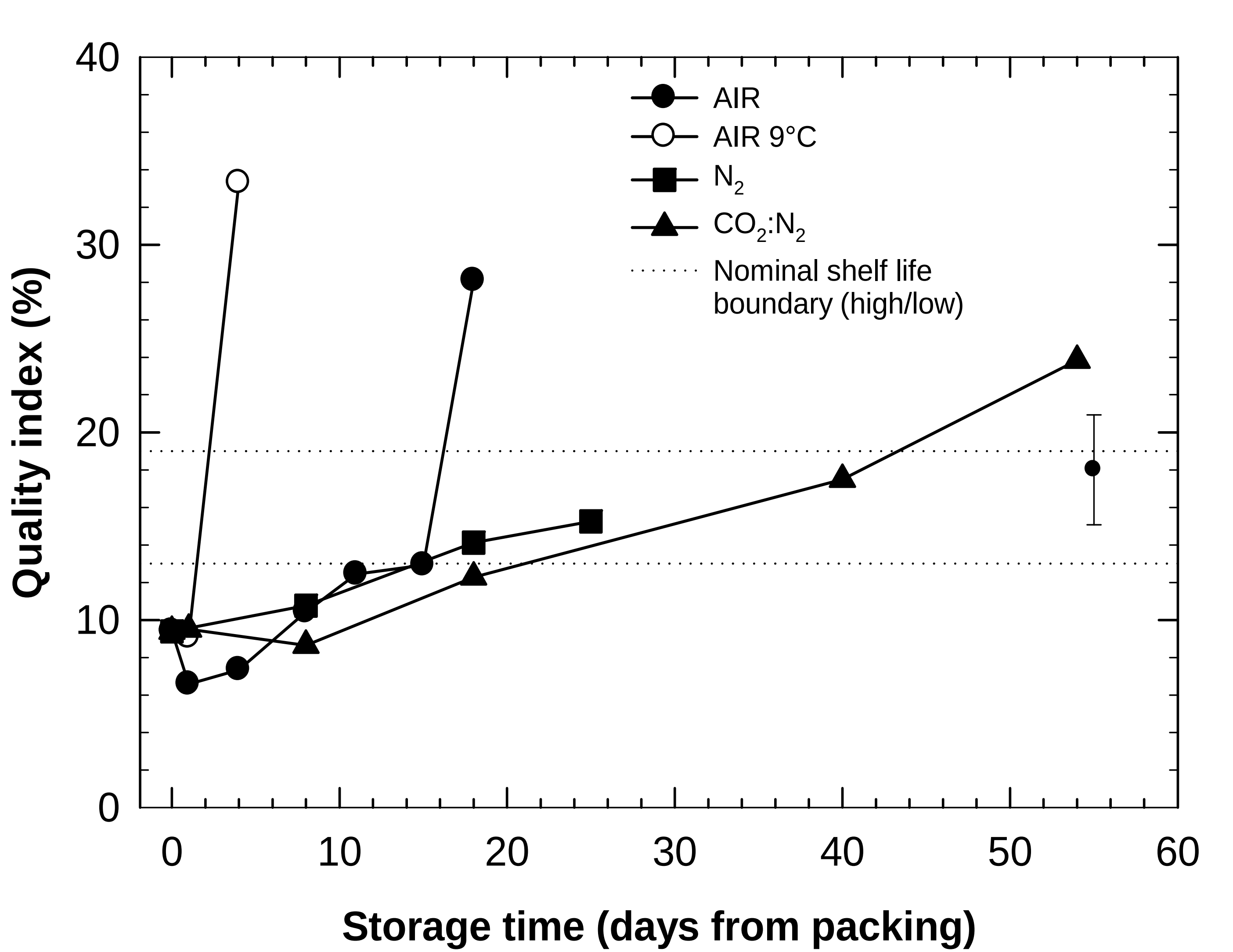
MAP Seafood

Our method

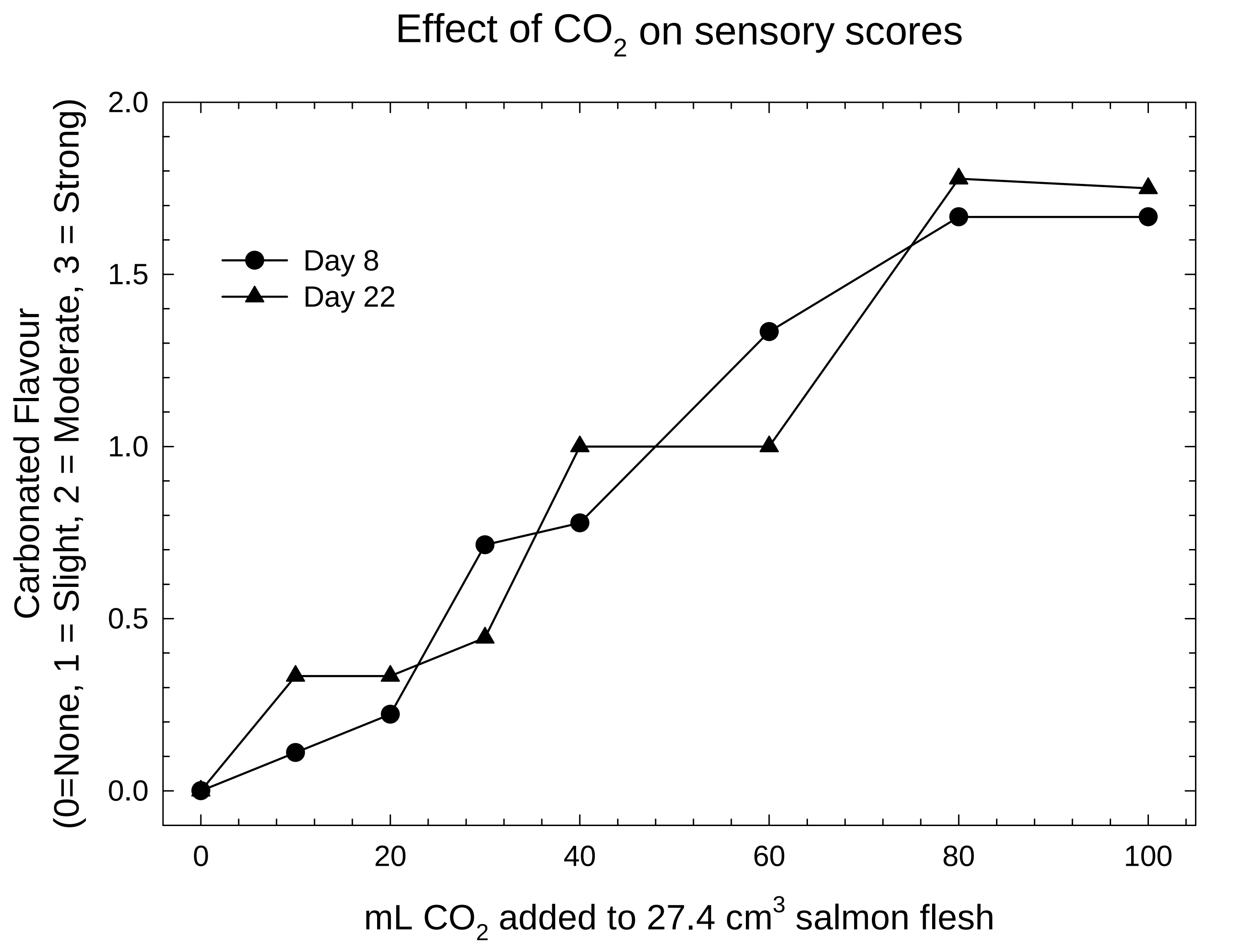
- Model effects of temperature, gas mix, fish volume, gas volume, fish species, fish condition on shelf-life
- Obtain data on:
  - Microbial growth rates
    - Principal spoilage organisms
  - Sensory evaluation
  - Physical, chemical, and biochemical data (Drip loss, colour changes, ATP breakdown products, basic amines, pH, Eh, TBA, peroxide and anisidine values)
  - Determine chemical cues (GCO-GCMS)

MAP Salmon Results

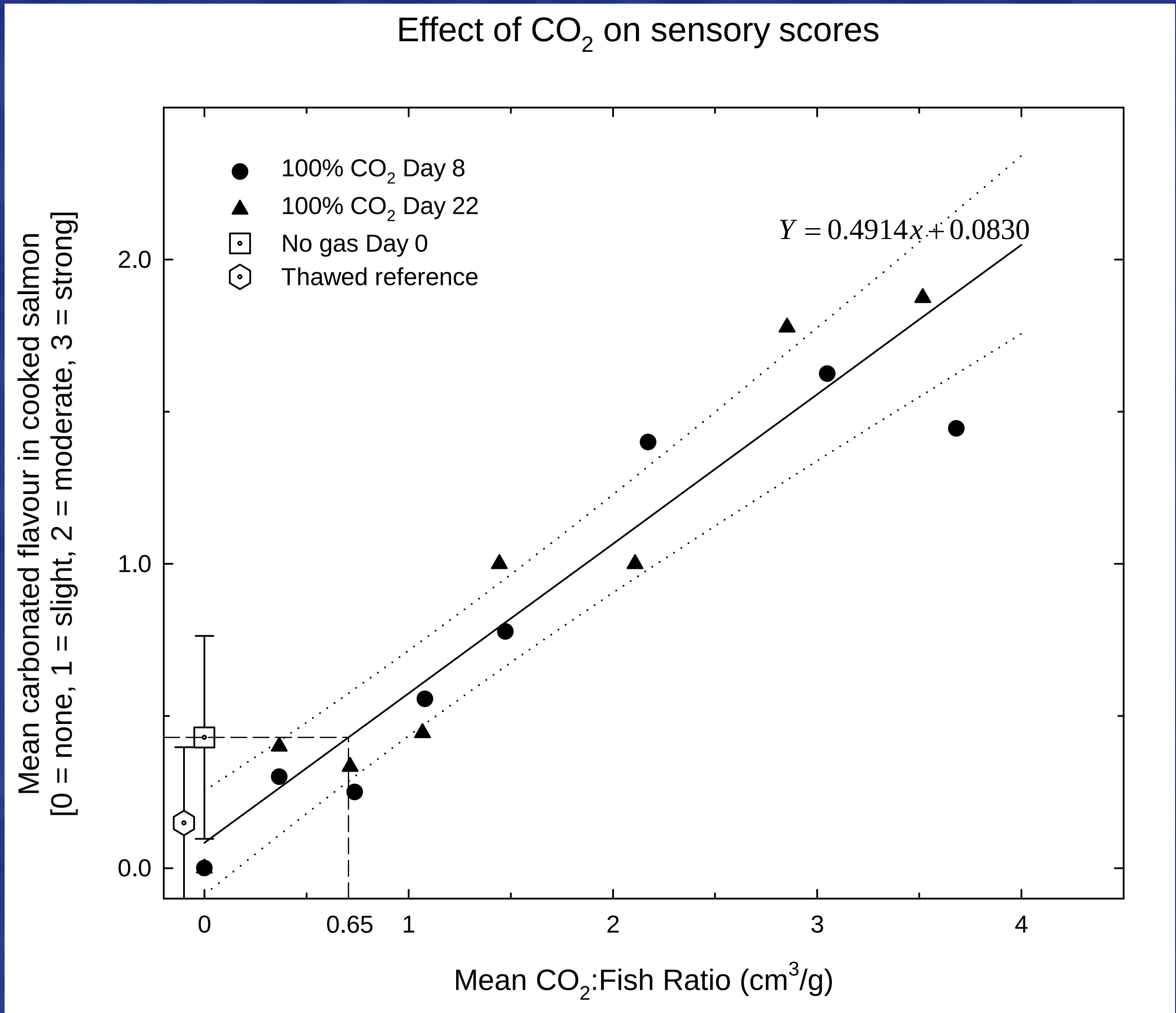
Effect on sensory scores



Carbonated flavour vs CO_2



Carbonated flavour vs CO_2



CROP & FOOD RESEARCH
Mana Kai Rangahau

MAP Salmon Results

- **The amount of dissolved CO_2 is determined by:**
  - **Gas mix**
  - **Fish:gas ratio**
  - **Fish composition (e.g. % lipid)**
- **Gas laws define a relationship between fish:gas ratio, gas mix and solubility of gas in product**
- **We can therefore design a gas pack with a particular fish:gas ratio so that the right amount of CO_2 is absorbed into the product**

Mana Kai Rangahau

Future Research Plans

Species by species evaluation.

- **Select species-specific quality evaluation markers.**
- **Use the best current practice to supply the species as a fresh seafood.**
- **Optimise packaging regimes for the species by defining the fish:gas ratio and gas mixture producing maximum bacterial inhibition with minimum negative impact on the sensory quality.**
- **Select other optimum parameters (e.g. temperature constraints) for successful transportation and marketing of the fish giving a high quality shelf life of at least 21 days.**
- **Design an integrated fresh fish regime and carry out industry-based validations.**

Conclusions

CROP & FOOD RESEARCH

Mana Kai Rangahau

- **MAP does have considerable potential for extended shelf-life seafood products.**
- **Temperature control and high quality raw material will always be critical.**
- **Each product must be carefully evaluated for benefits of MAP.**
- **Factors such as the effect of MAP on drip loss and product appearance will vary with different products**
- **Gas composition and fish:gas ratio need to be defined for each product**

Mana Kai Rangahau

New Zealand Institute for Crop & Food Research Ltd.

Questions?