Technology Transfer:
University Research to Industry

Ohmic Cooking for Accurate Evaluation of Surimi Gels

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Background

- Surimi Processing (water washing) does not remove all proteolytic enzymes:

  
  ![Graph showing enzyme activity before and after washing](image)

P239, Surimi and Surimi Seafood (Park, 2005)

An et al. (1994) J Food Sci
Background

- Proteolytic enzymes degrade myofibrillar proteins at 40-75°C depending on species:

An et al. (1996) Trends Food Sci and Tech

P232, Surimi and Surimi Seafood (Park, 2005)
Cold/Temperate Water Species
Pacific Whiting

Tropical/Warm Water Species
Lizard Fish

An et al. (1994) J Food Sci

Dr. Yongsawatdigul’s Lab
Background

A) Gelation properties of surimi is evaluated using gels cooked in water bath (Slow heating)

B) Surimi seafood (Crabstick) is processed in a continuous thin sheet (Fast heating)
A) One sausage (150 g) cooking in 14.5 L water (90°C) for 10 minutes.

90°C final cook temperature
3 cm diameter sausage

B) Ohmic: 250 Volt to 93°C – 3 cm dia tube
Heating of a surimi test gel cross-section with 3 cm (ID)... requires

>35 min to reach 90 °C in the center

The center, where gel punch is made, is exposed to enzyme active temperatures for > 4 min, resulting in poor gel value (inaccurate analysis)
Discrepancy

- **Slow cooking** for Test Gels
- **Fast cooking** for Finished Products (Crabstick)
Test Gel Cooking Device that mimics *Fast Cooking* (Crabstick Line) is

Greatly Needed!
Heat is generated by **Electrical Resistance** between two electrodes.
Objectives

• To measure the feasibility of ohmic heating that mimics crabstick production for accurate gel quality assessment.

• To determine gel softening phenomena according to their grade and/or species.
Materials

- Pacific whiting surimi
- Alaska pollock surimi (AA, KA, RA)
- Catfish surimi
- Arrowtooth Flounder surimi
- Giant squid surimi
- Surimi added with dried egg white
- Surimi added with whey protein concentrate
Cooking Methods

• **Water Bath**
  – Sausage casing (3.0 cm Dia) at 90°C for 30 min

• **Ohmic Cooking**
  – 200 V or 250 V heating (50 - 35 sec cooking) with or without holding at 90°C for 0, 45, 90 sec
Ohmic Gels

Water Bath Gels
Texture Analysis

• All Gels were subjected to penetration using spherical probe (5 mm dia) after being equilibrated to room temp.

• Crosshead speed: 1 mm/sec

• Measured breaking force (g) and deformation (mm) at rupture
The figure shows the relationship between heating rate (°C/min) and shear stress (kPa) and shear strain for Pollock and Whiting. The x-axis represents the heating rate, ranging from 1 to 30 °C/min, while the y-axis represents shear stress and shear strain, ranging from 0 to 60 kPa and 0 to 3, respectively. The bars indicate the amount of gel formation at different heating rates:

- **Pollock**:
  - At a heating rate of 1 °C/min, there is no gel formation.
  - At 5 °C/min, there is no gel formation.
  - At 10 °C/min, there is no gel formation.
  - At 20 °C/min, there is no gel formation.
  - At 30 °C/min, there is no gel formation.

- **Whiting**:
  - At a heating rate of 1 °C/min, there is no gel formation.
  - At 5 °C/min, there is no gel formation.
  - At 10 °C/min, there is no gel formation.
  - At 20 °C/min, there is no gel formation.
  - At 30 °C/min, there is no gel formation.
Pacific Whiting

2% salt, 78% moisture

[Graph showing force (g) and deformation (mm) for different Ohmic Cooking times (WB, 0 s, 45 s, 90 s) at 200 V and 250 V.]
RA Alaska pollock

2% salt, 78% moisture

- 200 V (g)
- 250 V (g)
- 200 V (mm)
- 250 V (mm)

Ohmic Cooking

- 0 s
- 45 s
- 90 s

Force (g)

Deformation
AA Alaska pollock  2% salt, 78% moisture

Deformation

Force (g)

200 V (g)  250 V (g)  200 V (mm)  250 V (mm)

WB  0 s  45 s  90 s  Ohmic Cooking
Catfish Surimi (200 V 90 s)

3% salt addition and no moisture adjustment

**Force** vs. **Deformation**

- **WB**
  - Force: 250 g
  - Deformation: 350 mm
- **OH**
  - Force: 450 g
  - Deformation: 1100 mm
Arrowtooth Flounder Surimi

Water Bath/cooked in 3 cm (dia) casing

3% salt, no moisture adjustment

- Force
- Deformation

No gel

60-90
90
Ohmic

Water Bath/cooked in 3 cm (dia) casing
Threadfin bream
2% salt, 78% moisture

![Graph showing force and deformation for WB and OH conditions. The graph compares force (g) and deformation (mm) for two conditions: WB and OH. The force (g) for WB is around 300-350, and for OH is around 400-450. The deformation (mm) for WB is around 12-15, and for OH is around 18-20. There is a trend indicating an increase in force and deformation as the condition changes from WB to OH.]
Bigeye snapper

2% salt, 78% moisture
Goatfish

2% salt, 78% moisture
Lizardfish

2% salt, 78% moisture
Pacific Whiting Surimi Texture as Affected by Cooking Method and Protein Additives

2% salt, 78% moisture

Role of Ohmic - controlling proteolytic enzyme
Role of DEW - inhibition & gelling ability
Alaska Pollock (RA) Surimi Texture as Affected by Cooking Method and Protein Additives

2% salt, 78% moisture

[Graph showing the effect of cooking method and protein additives on surimi texture.]

- Cooking Method: WB, OH, DEW, WPC
- Protein Additives: CON, WB, OH, DEW, WPC

Deformation (mm) vs. Force (g) for different cooking methods and protein additives.
Whiteness of Surimi Gels as affected by cooking methods and additives

Water Bath Cooked
- PW WB
- AP(RA) WB

Ohmic Cooked
- PW/200v
- AP(RA)/200v

Whiteness, L* - 3b*

0% additives

2% DEW

2% WPC
Current Efforts

• Microwave Cooker
  – Great results
  – Too large to be portable
  – >US$ 60,000 ?
  – Failed to penetrate

• Ohmic Cooker
  – Great results
  – Small enough to be portable
  – About US$15,000 ?
  – Just introduced by Kami Steel (Seattle, WA, USA)
CONCLUSIONS

• Ohmic heating enabled to cook 3 cm diameter sausage properly and rapidly.

• Pacific whiting surimi, catfish surimi, arrowtooth, RA grade pollock surimi and all tropical surimi significantly improved their gel values by ohmic cooking: Accurate Quality Assessment (Not Cheating) – More Values

• Ohmic gels were relatively whiter than waterbath gels.
FAST Cooking Ohmic (Joule) Heating:

- Better Utilization,
- More Value, and
- Accurate Analysis of Surimi

- More Profit and Better QC

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