Harvesting, handling practices and processing of bluefin tuna captured in the trap fishery: possible effects on the flesh quality

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The international commerce of BFT dates back to the 5th century B.C. Phoenicians established a number of colonies along the Mediterranean coast in the vicinity of saltpans.
The eating of tuna has been closely connected with the advancement of conservation methods:

- **Garum** (from the Greek word *garos*) derived from flesh, blood and viscera
- Salt, for processing tuna and prepare Dry tuna
- Olive oil, for Tuna in oil conservation
- Freezing
• The tuna commerce was improved considerably with the development of rapid transportation, packaging and chilling in response to the demands of foreign market.
THE HIGHEST DEMAND FOR TUNA IS FOR RAW CONSUMPTION IN THE FORM OF SUSHI AND SASHIMI

INSPECTION OF QUALITY OF PRODUCT IS EXTREMELY IMPORTANT

HIGHER QUALITY PRODUCTS ATTRACT HIGHER PRICES AND THESE MEANS HIGHER RETURNS TO MANAGERS, AND PAYMENTS FOR THE CREW
THE CONCEPT OF QUALITY FISH OR FRESH FISH

What buyers Look for?

EMPIRICAL FACTORS
translucence, transparency, tissue texture, smell, fat content
THE CONCEPT OF QUALITY FISH OR FRESH FISH

Determinants of Fish Quality

BIOLOGICAL FACTORS (not controlled by human)
- age, size, sexual maturity, parasites or disease, feeding

NON-BIOLOGICAL FACTORS (within the CREW control)
Fishing method, handling, chilling and storage techniques
CAUSE AND EFFECT OF STRESS IN FISH

Primary Responses
- e.g., increases in corticosteroid and catecholamine hormones
- alterations in neurotransmitter activity

Secondary Responses
- e.g., metabolic changes (increases in glucose, lactate; decrease in tissue glycogen)
- cellular changes (increased HSP production)
- osmoregulatory disturbance (chloride, sodium, water balance)
- changes in hematological features (hematocrit, leukocrit, hemoglobin)
- changes in immune function features (lysozyme activity, antibody production)

Tertiary Responses
- e.g., changes in whole-animal performance characteristics
  (growth, swimming capacity, disease resistance)
- modified behavioral patterns
  (feeding, aggression)

Perceived Stressors
- e.g., stimuli evoking startle response
- presence of predator

Physical Stressors
- e.g., handling, capture, confinement, transport

Chemical Stressors
- e.g., contaminant and pollutant exposure
- low oxygen acidification
CAUSE AND EFFECT OF STRESS: MATTANZA
CAUSE AND EFFECT OF STRESS:

GAFFING
CAUSE AND EFFECT OF STRESS

STORAGE & TRANSPORT
CAUSE AND EFFECT OF STRESS:

BLEEDING & EVISCERATION
CAUSE AND EFFECT OF STRESS:

CHILLING
Objectives

- Investigate the primary (neuroendocrine) and secondary (plasma changes) physiological response of bluefin tuna under stress-free and stress state

- Identify relationships between stressors and color variability of muscle

- Study the color variability of muscle tissue under the effects of air exposure over time

- Study the color variability of muscle tissue over time during defrosting

Results can be useful for:

Trap Managers, Fishermen, Wholesaler ...
How is the physiological response of bluefin tuna
- before the fishing phase (no-stress condition)
and
- after the fishing (stress condition)?
EXPERIMENTAL DESIGN: blood sampling

Death chamber

The west chamber
EXPERIMENTAL DESIGN: blood sampling

Stress state (the Lift or Mattanza; n = 14)

Death chamber

The west chamber
Cortisol (ng/ml) was determined using a diagnostic ELISA immunoenzymatic kit (DRG® Cortisol ELISA).

Lactate (μmol/ml) was determined using a diagnostic kit (BM-Lactate, Roche Diagnostics).

Glucose (mg/dL) by the chemistry analyzer MINDRAY-BS 120 (Mindray Medical International Ltd).
ANALYSIS OF DATA

• Data were analyzed using descriptive statistics plotting box and whiskers plots (mean ± S.D.)

• Student’s t-test ($\alpha = 0.05$) considering the experimental condition “No-stress Vs. Stress” conditions.
• Does colour of muscle changes **Before Vs. After fishing**?

• Does colour of muscle changes **after landing**?

• ... and after defrosting (for cannery)?
AFTER THE MATTANZA ...

1. Transfer
2. Landing
3. Inspection
4. Evisceration
5. Chilling
6. Freezing-Defrosting (for cannery)
EXPERIMENTAL DESIGN: muscle sampling

FRESH SAMPLES (n = 48)

Time 1 (90’)

Time 2 (180’)

Time 3 (240’)
EXPERIMENTAL DESIGN: muscle sampling

DEFROSTED SAMPLES (n = 16)

Time 1 (90’)

Time 2 (180’)

Time 3 (240’)

- [Image of defrosted meat samples at different times]
ANALYSIS OF MUSCLE: methods

Tuna – Box (self-made using FOREX®)
Two fluorescent lights of 12W with a 5.000K color temperature
High resolution Digital Camera (12M pixel)

Alternative: Konica-Minolta Handle spectrophotometer K400
ANALYSIS OF MUSCLE: methods

High resolution pictures (~500K JPEG format)
Pictures were standardized (white balance)
ANALYSIS OF MUSCLE: methods

- Tracing of ROI (region of interest) of slices by Picture Color Analyzer (Otaka, 2002)
- Calculation the number of pixels for three monochromatic channels, RGB
- Percentage value of the surface was calculated using: total area/(pixel*255) considering a scale from 0 = white and 255 = black.
- Percentages of R, G, B on the overall pixels is: Rp=R/(R+G+B); Gp=G/(R+G+B), Bp=B/(R+G+B),

Color Space: RGB (Red, Green, Blue)
ANOVA was performed to test the hypothesis that the variability of percentage of channels Rp, Gp, Bp differed over the three time intervals (90’ – 180’ – 240’) for Fresh and Frozen experiments.

Two-way ANOVA (α = 0.05) was applied to test for differences Fresh Vs. Frozen experiments.

Data were processed using Brodgar v2.6.6 (Highland Statistic Ltd. UK).
FIRST ISSUE: blood stressors accumulation
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### FIRST ISSUE: blood stressors accumulation

<table>
<thead>
<tr>
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<th>Before</th>
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<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
<td>min</td>
<td>max</td>
<td>mean</td>
<td>sd</td>
<td>min</td>
<td>max</td>
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<tr>
<td>Cortisol (ng/ml)</td>
<td>73.3</td>
<td>9.5</td>
<td>60.0</td>
<td>85</td>
<td>148.0</td>
<td>21.2</td>
<td>106.0</td>
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<tr>
<td>Lactate (µmol/ml)</td>
<td>5.7</td>
<td>2.9</td>
<td>1.2</td>
<td>9.7</td>
<td>17.0</td>
<td>2.2</td>
<td>13.8</td>
<td>21</td>
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<tr>
<td>Glucose (mg/dL)</td>
<td>83.5</td>
<td>8.0</td>
<td>78.0</td>
<td>97.9</td>
<td>128.6</td>
<td>19.3</td>
<td>102.0</td>
<td>168</td>
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Student’s t-test showed significant differences for all pairwise comparisons:
- **Cortisol**: Before Vs. After;
- **Glucose**: Before Vs. After;
- **Lactate**: Before Vs. After
SECOND ISSUE

Colour changes in muscle
SECOND ISSUE: colour changes in muscle

There is no significant difference of flesh color before/after stress state of Mattanza
SECOND ISSUE: colour changes in muscle

FRESH TUNA

**Drop of channel RED**  
**Enhance of channel GREEN and BLUE**

ANOVA (P < 0.05)
SECOND ISSUE: blood stressors accumulation DEFROSTED TUNA

Enhance of RED, steady GREEN, decrease BLUE ANOVA no-significant (P > 0.05)
# Equivalent Colour Scale (ECS)

## Fresh Tuna

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<td>CARDINALE MOLTO PALLIDO</td>
<td>ROSSO MOLTO PALLIDO</td>
<td>GRIGIO</td>
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<tr>
<td>R</td>
<td>114</td>
<td>112</td>
<td>99</td>
</tr>
<tr>
<td>G</td>
<td>71</td>
<td>76</td>
<td>79</td>
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<tr>
<td>B</td>
<td>71</td>
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## Equivalent Colour Scale (ECS)

### FRESH TUNA

*(keep at environmental temperature)*

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<td>R</td>
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<td>B</td>
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### Equivalent Colour Scale (ECS)

**DEFROSTED TUNA**
*(keep at environmental temperature)*

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<td>94</td>
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<td>B</td>
<td>102</td>
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<td>B</td>
<td>84</td>
<td>73</td>
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Equivalent Colour Scale (ECS)

• This Labeling is “no-subjective”
• Could be useful in the qualitative inspection of tuna
• It is useful to verify freshness (Time)
• To avoid food scams (which generate diverse values of RGB)
Malpractices: red-color
GASSING FLASH WITH CARBON MONOXIDE
CONCLUSION

Bluefin tuna is a high quality species and much prized.
1) reduction of the level of hyperactivity of tunas before the mattanza;

2) bleeding the specimens instantly and chilling them rapidly on-board

3) reducing transfer time from the trap site to the factory

4) adopting relative quality rank-colouring for labelling specimens is a useful tool for fresh market.
Management: QUOTA
HIGHER QUALITY PRODUCTS ATTRACT HIGHER PRICES AND THESE MEANS HIGHER RETURNS TO MANAGERS, AND PAYMENTS FOR THE CREW.

THIS IS AN EXPEDITIOUS STRATEGY IN THIS "NICHE" TUNA FISHERY TO MITIGATE THE EFFECTS OF QUOTA REDUCTION.
Thank you

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- Consociazione Tonnare Sarde & Ligure Sarda Spa. (Isola Piana and Portoscuso Traps, Italy)
- ‘Tonnarotti’ fisherman