Lighting Conditions Affect Perception of Doneness and Willingness-to-eat Turkey Patties

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Background

- Color and visual appearance are the most common way to determine meat doneness among consumers
  - Most use only external or internal color to judge doneness
- Perception of color can be affected by many factors
  - Lighting, surrounding colors, previous experience, etc.
- Majority of studies with perception of color are done under standardized conditions
  - Can be difficult to apply to real world application
  - Color of meat is “metameric” – the color can change depending on lighting source.

Methods of checking meat doneness at home*

<table>
<thead>
<tr>
<th>Method</th>
<th>% of Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juice - amount</td>
<td>23%</td>
</tr>
<tr>
<td>Food thermometer</td>
<td>34%</td>
</tr>
<tr>
<td>Firmness of the meat</td>
<td>35%</td>
</tr>
<tr>
<td>Cooking time</td>
<td>45%</td>
</tr>
<tr>
<td>Color of meat (outside)</td>
<td>50%</td>
</tr>
<tr>
<td>Juice - color</td>
<td>51%</td>
</tr>
<tr>
<td>Color of meat (inside)</td>
<td>84%</td>
</tr>
</tbody>
</table>

*Asked after completion of study
Background

- Lighting regulations changed with EISA 2007 – Phased out in Europe, then in Canada, then in US, slowly being phased out in other countries
  - “Inefficient” lighting phased out in 2012 – 2014
  - Traditional 60-watt light bulbs no longer manufactured or sold in many countries
- Unknown how changes in lighting will affect consumer perception
Alternative Lighting is “Hot” in Kitchens (and Restaurants) for tasks and ambiance.
Objective

Evaluate the effect of lighting sources and endpoint temperature on consumer perceptions of doneness and likeliness to eat
First Issue – Consistency of Evaluation Samples

- Meat color is difficult to evaluate
- Instruments evaluate under a standard lighting condition – not alternative lighting conditions
- Humans are the ultimate evaluator, but it takes time
  - Samples change over time
  - Photographs must be validated
OBJECTIVE: DETERMINE IF PHOTOGRAPHS CAN BE VALIDATED AS AN ALTERNATIVE TO ACTUAL MEAT SAMPLES FOR USE IN TESTING COLOR OF MEAT IN VARIOUS LIGHTING CONDITIONS
Methods Overview

- Fresh ground turkey (93% lean) formed into ¼ lb. patties
- Cooked on double-sided electric grill to specific temperature
- Photographed at each temperature
Factors

- Patties were cooked to 1 of 6 temperatures
  - Below, at, and above recommended temperature
  - Cooked to each temperature in triplicate
Photographs

- Canon EOS Rebel T4i camera equipped with an 18-135mm lens
- Samples placed in light box with 2 external 5500K light bulbs
- 18% grey reference card used for color balance
- RAW photographs adjusted in Adobe Photoshop for color accuracy
Photography

- Patty cut in half and stacked to maximize view of interior
- Evaluated by descriptive panel against fresh cooked patties for:
  - Accuracy of color
  - Behavior when moving between lighting conditions
Photograph evaluation

- Photographs of patties cooked to each temperature given blinding codes and randomized
- Evaluated by trained descriptive sensory panel
- Compared to freshly cooked samples under simulated daylight conditions
  - Panelists chose photograph(s) that matched sample in appearance by consensus
Matching photographs were then evaluated under various lighting conditions.
Photographs were found to behave similar to samples.
Panelists were able to match photographs to samples cooked to the same temperature under each lighting condition.

- 60 Watt Incandescent
  - Traditional light bulb
- 43 Watt Halogen
  - New standard light bulb
- 13 Watt Compact Fluorescent
  - CFL
- LED
  - 60 watt equivalent
- LED
  - Daylight

Consumer Study
Consumer study

- 104 participants
  - Convenience sample used
  - 18-64 years old
  - Had to have prepared or eaten ground poultry within last month
- 81% consumed poultry within past week

Ages of Participants

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29</td>
<td>17%</td>
</tr>
<tr>
<td>30-39</td>
<td>21%</td>
</tr>
<tr>
<td>40-49</td>
<td>15%</td>
</tr>
<tr>
<td>50-64</td>
<td>47%</td>
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</tbody>
</table>

Gender

- Male
- Female
Consumer study

- Consumers evaluated each picture under each lighting source
- 14 pictures evaluated
  - Covered 6 temperatures
- 5 different lighting sources

- Temperatures:
  - 135°F
  - 155°F
  - 160°F
  - 165°F
  - 170°F
  - 175°F

- 3 photographs each:
  - 60 Watt Incandescent
  - 43 Watt Halogen
  - 13 Watt Compact Fluorescent
  - LED Soft White
  - LED Daylight
Consumer study

- 70 photos total evaluated
  - 14 photos x 5 booths
- Rated each photo for:
  - Degree of doneness
  - Likeliness to eat

Sample: 710

Considering everything about this sample, please rate the degree of doneness of 710.

<table>
<thead>
<tr>
<th>Extremely Undercooked</th>
<th>Moderately Undercooked</th>
<th>Slightly Undercooked</th>
<th>Just About Right</th>
<th>Slightly Overcooked</th>
<th>Moderately Overcooked</th>
<th>Extremely Overcooked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

How likely would you be to eat a meat patty that is this level of doneness?

<table>
<thead>
<tr>
<th>Very Unlikely</th>
<th>Unlikely</th>
<th>Somewhat Unlikely</th>
<th>Undecided</th>
<th>Somewhat Likely</th>
<th>Likely</th>
<th>Very Likely</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
Effect of endpoint temperature on consumer perceptions

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Doneness</th>
<th>Likeliness to eat</th>
</tr>
</thead>
<tbody>
<tr>
<td>155°F</td>
<td>2.09&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.13&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>160°F</td>
<td>3.23&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.89&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>165°F</td>
<td>3.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.48&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>170°F</td>
<td>3.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.70&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- Perception of doneness and likeliness to eat increased as temperature increased
- Shows that pictures did work as intended
- Likelihood to eat increased faster than doneness

Within a column, means that share a letter are not significantly different at p<0.05

A score of 4=just about right or undecided. <4 is undercooked or not likely to eat; >4 is overcooked or likely to eat.
Effect of Lighting & Temperature

% LIKELY TO EAT

MEAN DONENESS SCORE

Temperature Increase

*Significantly equal or higher than JAR
Results: Effect of Lighting & Temperature

Likelihood to eat significantly increased from 155°F to 160°F.

Most consumers would not eat samples that were undercooked by 10°F.
Results: Effect of Lighting & Temperature

Up to half of the consumers said they would likely eat samples cooked to a similar doneness of those at 160°F, lower than the recommended temperature.
Results: Effect of Lighting & Temperature

Some lighting conditions increased perception of doneness and likeliness to eat, such as LED, 43 watt, and 60 watt light bulbs.
Results: Effect of Lighting & Temperature

Only one sample at 165°F was rated as just-about-right, under the LED lighting.
Range of colors seen in Cooked Poultry Patties Under Various Lighting Conditions
Conclusions

- This study suggests that consumers are not good at judging doneness of ground turkey under any lighting conditions.

- Some light bulbs such as soft-white LED and 43 watt halogen had the biggest impact on perception.

- Samples at 160°F had between 41-50% of consumers likely to eat a sample cooked to that doneness.
  - Likelihood to eat rose faster than perception of doneness.
  - Many consumers stated they would be likely to eat a sample even if they thought it was “slightly undercooked.”
Conclusions

- Samples at 160°F (less than recommended temp) had between 41-50% of consumers WILLING TO EAT
  - Willingness to eat rose faster than perception of doneness

- Consumers more likely to undercook their poultry when cooking under certain lighting (ENVIRONMENTAL) conditions

- CONSUMER MESSAGE: Lighting (Environment) has changed making what you used to do less accurate. Color is not an accurate indicator of doneness – use a thermometer.
Acknowledgment

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