Hurry-up and Wait! Accelerated Microbiological Shelf-life Studies for Foods.

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A Bit of Background

- Who in the world is Adam Borger?
  - B.S. in Food Science from *THE* Ohio State University.

  - M.S. in Food Microbiology from the University of Wisconsin-Madison.
  - Microbiologist for Kraft Foods (1998 – 2009).
  - Microbiologist for Rich Products (2009-2013).
  - Outreach Program Manager for University of Wisconsin's Food Research Institute (2013 - ?).

Topics

- What’s the goal?
- What are you determining?
- What could go correctly.
- Questions to ask before and after your study..

What is the goal?

SPEED

What is the goal?

SPEED™

- Place product under conditions that accelerate the "reactions" you are monitoring in a food product.
  - Typically, higher temperatures.
- Use this information to determine shelf-life of the food lower temperatures.
- Use these studies or conditions to predict problems after products are in commerce.
- Use these studies to determine if product should be released into commerce.

What are you determining?

- Shelf-life based on:
  - Spoilage
    - Product appearance during temperature abuse.
      - Fat separation; syneresis; other quality defects.
    - Oxidation.
    - Rancidity.
    - Microbiological limits.
  - Pathogen Growth
    - Time to a certain level of microbes in the food.
    - Time to toxin formation.
    - Perhaps time to cell death?

Examples

- Aseptic beverages, puddings, beverages, other items.
  - Somewhat routine to store at elevated temperatures and look for bloated packages.
  - Indicative of contaminants present.
  - Pretty sound temperature abuse and observational conditions.
    - These are typically stored at ambient temperature so what's the correct accelerated temperature?
- Cook-in-bag or hot-filled products.
  - A little more difficult than above.
  - Process cheese chubs, Salad dressings, etc.
  - What might grow at elevated temperatures?
    - Spores? Would this actually happen at lower temperatures?
- Ready-to-eat, open exposed products.
  - Sliced meats, cheeses, cold-packed cheese, yogurt, salads/kits, etc.
  - Probably the most difficult. So many possible contaminants.
- What about raw products?

What could go correctly?

- You will arrive at a **dependable** set of data that will allow you to *easily* predict the shelf-life of a food product and *the exact moment* when the product may suffer microbiological spoilage.
- This dependable and infallible set of data will reduce days, weeks, and months of challenge studies to predict microbiological growth thus saving your company thousands of dollars and earning **YOU** high praise amongst your colleagues.

Questions to consider when performing a study.

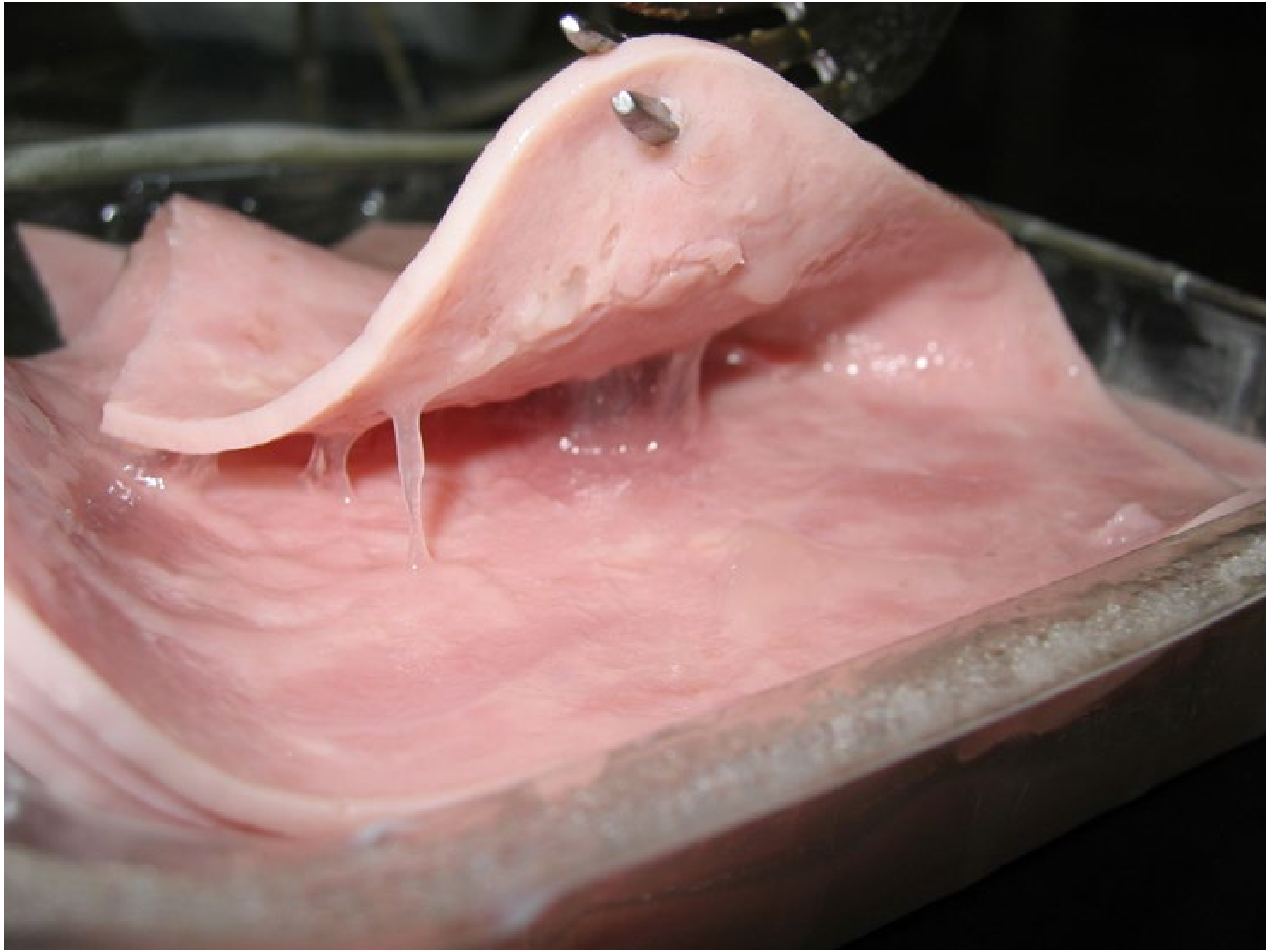
- What happens to the product during storage at elevated temperatures?
  - Moisture migration.
    - Mold growth? Bacterial growth?
    - Will other antimicrobial constituents migrate with this moisture?
  - Fat separation.
    - Does this impact behavior of microbes in the product?
    - Different phases?
  - Gums, water binding affected?

Questions to consider when performing a study.

- How can you know which spoilage microbes are of interest?
- Example: Ready-to-Eat sliced meat product
  - What might spoil this product?
    - Lactic acid bacteria
    - Yeasts
    - Molds
    - Gram negative microbes
    - Spore-formers

Questions to consider when performing a study.

- Where are these spoilages microbes coming from?
- Can you be sure that they are all accounted for? Do you need to?
- How do these different microbes behave in your product at elevated temperatures?
- Are these the same microbes that would grow in your product at a lower temperature?
  - Might there be some that grow faster than others?
  - Can you use these to predict shelf-life?



The Child’s Birthday Party Scenario.

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- Birthday party for our 8 year-old (Design of study)
  - We will examine how our scenario impacts the shelf-life (time-to-meltdown) of the product (birthday party).
- Mom (Susan) says "2 hours max."
  - Dad (Adam) says "Oh, 3 hours would be fine."
    - 1.5 times the anticipated shelf-life.

The Child's Birthday Party Scenario.

- Daughter's neighborhood friends invited.
  - Known population of organisms. Easily identifiable behavior and known response in environment during normal conditions based on history.
- Daughter's one daycare friend also invited. Mom drops her off and is gone for 3 hours (Adam says "Oh, 3 hours would be fine.")
  - An organism that we don't really know or understand enters the picture.
  - How will this organism react in our environment?

The Child’s Birthday Party Scenario.

- Birthday party for 8 year-old is underway (Monitoring Results)
- August weather turns very windy and a soaking rain falls; no bounce-house, everyone in the house – for 3 hours.
  - Accelerated conditions begin to have an effect.
  - The daycare friend (Ava) begins to meltdown.
    - “I HATE juice!” “This is the worst party ever” through tears and sobbing.
    - The party is spiraling out of control at hour 2!

The Child's Birthday Party Scenario.

- By hour three Ava is still crying, our daughter is crying, other kids are either indifferent or angry.
  - The experiment may have been a success! We have learned that the accelerated conditions along with an unknown organism have indeed spoiled everything by hour 2.
  - But, what would have happened without the presence of Ava?
    - Do we dare repeat this study?

The Child’s Birthday Party Scenario.

- At the end of the party/experiment Mom and Dad are drinking…to their success???
    - Susan (Adam’s wife) uses this experiment as the standard for setting time limits on birthday parties from here on out – no longer than 1.5 hours as a conservative approach!
    - Adam swears to always listen to Susan….but is this faulty logic?
        - If Ava is not present (and hasn’t been since!) do we really need to cut the party so short?

Experimenting with accelerated shelf-life.

- Pick your temperatures.
  - Be sure to include your standard storage temperature for the product.
  - How long will this take?
- Determine your number of trials.
  - This may cause some confusion depending on results.
- Be aware of changes in formulation.
  - Do you have “worst-case” scenario data?
  - Is your new low-salt, clean-label, preservative-free item the “worst-case”?
  - Can you repeat all of these?

What counts as spoiled?

Setting up the experiment – spoilage determination

- What is spoiled?
  - 10^6 cfu/g?
  - Sight, smell.
  - Is anyone tasting these?
    - Could you accidentally give someone *Clostridium botulinum, C. perfringens of Staphylococcus aureus* poisoning if they did? How would you know?

Can you inoculate your product with isolates from previous incidents?

Q10 – Temperature Coefficient.

- Used for measuring enzymatic reactions.
- The factor by which the rate of spoilage increases when the temperature is raised by 10C.
- Allows for the prediction of a product's shelf life under real-life conditions based on the results of testing conducted at higher temperatures.
- It is unit-less and can be calculated with the equation:
  - $Q10 = (R2/R1)^{(10/(T2-T1))}$
  - R is the time it takes for a product to spoil and T is the temperature at which the testing is conducted.

Thanks to Mocon® for the information

Q10 – Hypothetical Example

- Vacuum-packed meal kit is tested at three different temperatures (T).
  - T1 = 4C; T2 = 14C; T3 = 24C
- Days to spoilage (R) are as follows:
  - R1 (4C) = 60 days
  - R2 (14C) = 30 days
  - R3 (24C) = 15 days
- Q10 = $(R2/R1)^{(10/(T2-T1))}$
  - $(30/60)^{(10/(14-4))} = (0.5)^{(10/10)} = 0.5$
  - $(15/30)^{(10/(24-14))} = (0.5)^{(10/10)} = 0.5$
- Dividing the *accelerated shelf-life days to spoilage* by the Q10 value predicts the lower temperature shelf-life:
  - 30 days divided by 0.5 = 60 days at 4C
  - 15 days divided by 0.5 = 30 days. Divide again by 0.5 = 60 days

Q10 – More Complicated Results

- Vacuum-packed meal kit is tested at three different temperatures (T).
  - T1 = 4C; T2 = 14C; T3 = 24C
- Days to spoilage (R) are as follows:
  - R1 (4C) = 60 days
  - R2 (14C) = 25 days
  - R3 (24C) = 3 days
- $Q10 = (R2/R1)^{(10/(T2-T1))}$
  - $(25/60)^{(10/(14-4))} = (0.42)^{(10/10)} = 0.42$
  - $(3/25)^{(10/(24-14))} = (0.12)^{(10/10)} = 0.12$

Q10 – More Complicated Results

- Days to spoilage (R) are as follows:
  - R1 (4C) = 60 days
  - R2 (14C) = 25 days
  - R3 (24C) = 3 days

Q10 = 0.42

Q10 = 0.12

- Dividing the accelerated shelf-life value by the Q10 value predicts the lower temperature shelf-life:
  - 25 days divided by 0.42 = 60 days at 4C
  - 3 days divided by 0.12 = 25 days at 14C.
    - Divide again by 0.12 = 208 days at 4C
  - 3 days divided by 0.42 = 7 days at 14C.
    - Divide again by 0.42 = 17 days at 4C

Q10 – More Complicated Results

- Days to spoilage (R) are as follows:
  - R1 (4C) = 60 days
  - R2 (14C) = 25 days
  - R3 (24C) = 3 days

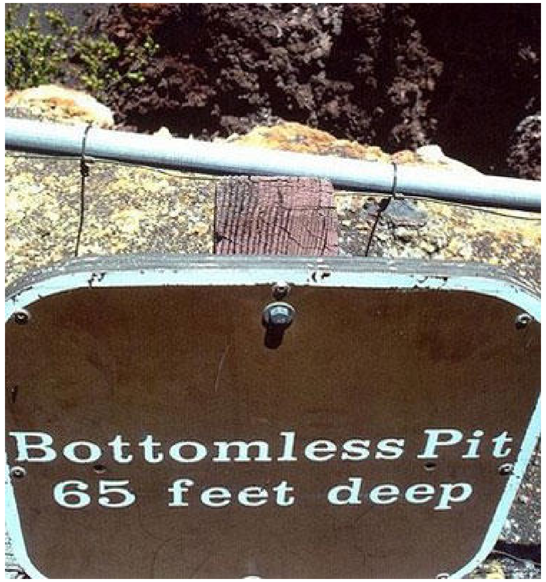
Q10 = 0.22

- Dividing the accelerated shelf-life value by the Q10 value predicts the lower temperature shelf-life:
  - 3 days divided by 0.22 = 13.6 days at 14C.
    - Divide again by 0.22 = 62 days at 4C

Who is ultimately going to use this information?

- Sales and marketing.
  - How do you explain this to them?
  - What happens if something goes wrong?
- Manufacturing locations.
- Other microbiologists.

- Can you be clear in your message?



Are there other sources of this information?

- Combase and other modeling sites – perhaps.
- Industry studies or laboratory studies – yes, but do you have access?
- Some dude sticking a product on his desk at the plant and looking at it every day.

Are there other sources of this information?

- Often VERY specific to your product.
- Perhaps pathogen data can be used from models and other published data.
    - Spoilage is very, very difficult to predict based on all of the factors stated beforehand.

In summary

- Accelerated microbiological shelf-life studies can be performed!
  - Depending on the product, the microbes of interest and a host of other factors.
- Predicting spoilage of products consistently and reliably can be very difficult.
  - Depending again on the host of factors mentioned above.
- Communicating results and possible future trends may be the most difficult aspect of all.

- Don’t ever host a child’s birthday party for more than 1.5 hours.

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