

Sustainability of the Food Supply Chain

Dennis R. Heldman Macy Award Address March 7, 2016



THE OHIO STATE UNIVERSITY

Challenges

- A global population of 9 billion by 2015
- Limited supplies of energy to produce and deliver a nutritious food supply
- Increasing concerns about impacts of all food supply chain activities on the environment
- An increasing demand for a finite supply of fresh water
- A lack of concern about the losses and wastes in the food supply chain

Questions

- How do we improve the energy efficiency of processes used throughout the food supply chain?
- Why do we use fresh water to rinse residues, and as a carrier for cleaning and sanitizing agents, for food-contact surfaces?
- Do frozen foods need to be held at -18 C throughout the cold supply chain?
- Why do we use fresh water to dilute product solids created throughout food supply chain?
- How and where should we reduce food wastes?

2012 Report on Food Waste

FOOD CONSUMED VERSUS FOOD LOSS*



*Percentages calculated collectively for USA, Canada, Australia, and New Zealand.

2012 NRDC

NORTH AMERICAN* FOOD LOSSES AT EACH STEP IN THE SUPPLY CHAIN

*Percentages calculated collectively for USA, Canada, Australia, and New Zealand.



Source: Food and Agriculture Organization 2011

Materials Flow in U.S. Food System



A Mass and Energy Balance Challenge

- Consider a thorough analysis of the entire food supply chain, with emphasis on material balances, energy balances and fresh water balances.
- Integrated Life-Cycle-Assessment to optimize each stage, each process and each product category.
- These outcomes should be made available to all sectors within the food supply chain to encourage collaboration.

Life Cycle Energy for U.S. Food Supply



Water Utilization

- Available Water only 2.5% of the Earth's water is fresh water.
- Only 0.13 % of the total water is available for use in nature beyond the oceans.
- Current estimates are that water available for human use (including the food chain) is 4000 to 16,000 liters per capita per day.
- The projected world population is 8 billion by 2025.
- Projected water consumption is 3300 liters per capita per day by 2025.

from Schubert and Schuchmann (2011)

Demand for Water

- "Water Footprint" is the volume of water required to produce the goods and services consumed by an individual or community. [estimate at 4000 liters per capita per day for EU]
- "Virtual Water" is the volume of water used to produce a defined quality of a given product.
- "Virtual water" examples ---

Cane sugar = 150 liters/kg product Rice = 2900 liters/kg product Beef = 15,000 liters/kg product Glass of wine = 960 liters A hamburger = 16000 liters A 2g microchip = 16000 liters

from Schubert and Schuchmann (2011)

Energy Waste due to Product Loss



Wasted Energy and Water

- Using the quantity of edible food product ready for consumption, and the amount of energy used – approximately 6.7 x 10⁴ kJ/kg are required
- An estimated 4 liters of water are required per kg of edible food product.
- Since 27 % of the edible food is wasted, the amount of energy waste becomes --

300 trillion kJ per year

and --

175 billion liters of water per year

Mission: Improve efficiencies of processes for transforming raw food materials and ingredients into high quality and safe consumer food products.



Process Design

Mission: Process design and development improvements through application of process models and simulations

Projects

- Nuclear Magnetic Resonance Imaging for Effective Water Diffusivity in Lipids
 Sravanti Paluri; GRA. PhD Candidate
- Kinetics of volatile compound generation during roasting of coffee

Sangeetha Krishnaswamy, M.S. Candidate

Cleaning Operations

Mission: Fundamental parameters impacting the cleaning of food-contact surfaces; improving efficiencies of water and energy use during cleaning and sanitation operations

Projects

 Mechanisms for removing food residues during CIP operations

Mengyuan Fan; GRA, PhD Candidate

 Parameters influencing the fouling of heat exchanger surfaces

Chloe Huang; GRA, M.S. Candidate



Efficiency of Water Use



Frozen Foods

Mission: Understanding the freezing process; reducing energy demand during food freezing and frozen food storage, while enhancing product quality

Projects

- Changes in Protein-Water Dynamics Impact on the Ouality of Chicken Meat Post-freezing John Frelka; GRA, PhD Candidate
- Factors influencing the shelf-life of frozen foods Jeff Caminiti; GRA, M.S. Candidate
- Influence of environmental conditions during thawing of frozen foods

James Stone; GRA, M.S. Candidate

Frozen Product Temperature as Function of Location



Waste Streams

Mission: Analysis of food processing waste streams; recovery of valuable components from waste streams to ensure maximum utilization of raw food materials

Projects

 Management of waste streams created by CIP cleaning operations

Subbiah Nagappan; GRA, M.S. Candidate

 Applications of membrane technologies for managing waste streams from food processing operations
 David M. Phinney; Research Engineer

The Future



Lycopene -David M. Phinney

Food Waste

Mission: Reduction of food wastes; alternative technologies to monitor food quality during storage and distribution

Projects

- Development of a real-time shelf-life indicator for milk
 Aishwarya Badiger; GRA
- A demonstration of advanced shelf-life monitoring to reduce home food waste.

Dennis R. Heldman

2013 NRDC

20 PERCENT OF FOOD WASTED IN BRITISH HOUSEHOLDS IS DUE TO MISINTERPRETATION OF DATE LABELS. IF THE SAME WERE TRUE FOR THE U.S., IT WOULD MEAN THE AVERAGE HOUSEHOLD IS DISCARDING \$275-455 PER YEAR OF GOOD FOOD BECAUSE OF CONFUSION OVER DATE LABELS.

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USE BY

OCT 20

The only product for which this phrase is federally regulated is infant formula, and that's because the nutrients decline, not because it spoils.

There is not a legal definition for this phrase in most states, and it is almost never legally distinguished from "best before" or even "sell by".

Some products don't have any words to explain the date. In those cases, how are you to know whether the date is telling the store to sell it by then, or telling you it is at its best quality until then? This is typically used to indicate the "manufacturer suggestion for peak quality" of the product, not the food's safety.

Several different methods could have been used to determine this date, from lab tests to consumer satisfaction assessments. There's no way for you to tell which method was used.

20 states restrict stores from selling products after these dates; 30 states don't. Are people in those 20 states better off?

Some non-perishable foods have a date even though they'll be fine long after. Think of a box of mac-n-cheese.

A Real-Time Shelf-life Indicator



Figure 2: Depiction of the SMART DOT[™] color changing labels developed by Insignia Technologies Ltd. The label can be placed on a multitude of products and the color of the center circle changes as a function of time and temperature.

Barriers

- Customer reactions
- Retail market concerns
- Regulatory requirements
- Scientific/technology deficiencies
- Cost

Summary

Outcomes from research –

- Reduced energy requirements throughout food manufacturing operations
- Conservation of fresh water during food processing by reducing water in waste streams
- Reduced food wastes in the home through more refined communication of product shelf-life