Food Loss and Waste: A Multi-Billion Dollar Opportunity

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The Challenge

Every year, American consumers, businesses, and farms spend $218 billion a year, or 1.3% of GDP, growing, processing, transporting, and disposing food that is never eaten. That’s 52 million tons of food sent to landfill annually, plus another 10 million tons that is discarded or left unharvested on farms.

Meanwhile, one in seven Americans is food insecure.
1/4 to 1/3 of all food produced for human consumption is lost or wasted.

Here's the breakdown:

- 44% in developing countries
- 56% in developed countries

Those lost calories could fill hunger gaps in the developing world.

Calories lost or wasted per person, per day (out of a recommended 2,000):

- North America: 453
- Latin America: 414
- South / Southeast Asia: 414
- Sub-Saharan Africa: 545
- North Africa: 594
- Western Europe: 746
- Eastern Europe: 748
- Asia: 1,520

61% wasted by consumer
87% lost or wasted in production, storage, transport, etc.

Learn more at www.worldbank.org/foodpricewatch

Sources: FAO and World Resources Institute
63 Million Tons ($218 B) Annually in United States

ReFED Food Waste Baseline: Nearly 63M tons of waste per year

52.4 MILLION TONS
SENT TO LANDFILL

10.1 MILLION TONS
ON-FARM LOSS

= 62.5 MILLION TONS
FOOD WASTED IN
THE U.S. EVERY YEAR

FOOD WASTED BY WEIGHT — 63 MILLION TONS ($218 billion)

<table>
<thead>
<tr>
<th></th>
<th>Farms</th>
<th>Manufacturers</th>
<th>Consumer-facing Businesses</th>
<th>Homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>10M</td>
<td>1M</td>
<td>25M</td>
<td>27M</td>
</tr>
<tr>
<td>Percentage</td>
<td>16%</td>
<td>2%</td>
<td>40%</td>
<td>43%</td>
</tr>
<tr>
<td>Value</td>
<td>$15B</td>
<td>$2B</td>
<td>$57B</td>
<td>$144B</td>
</tr>
</tbody>
</table>

($218 billion)
U.S. Food Waste Challenge

USDA and EPA

U.S. Food Loss and Waste 2030 Champions

Food Recovery Hierarchy

- **Source Reduction**: Reduce the volume of surplus food generated
- **Feed Hungry People**: Donate extra food to food banks, soup kitchens and shelters
- **Feed Animals**: Divert food scraps to animal feed
- **Industrial Uses**: Provide waste oils for rendering and fuel conversion and food scraps for digestion to recover energy
- **Composting**: Create a nutrient-rich soil amendment
- **Landfill/Incineration**: Last resort to disposal

Most Preferred
Least Preferred
Agricultural Research Service

2000 Research Scientists, 90+ Research Locations, $1.4 B

Mission: Conduct research to develop and transfer solutions to agricultural problems of high national priority.
National Programs

Bring Coordination, Communication and Empowerment to the 660 Research Projects and 15 National Programs in ARS

Gene Lester
National Program Leader
Nutrition, Food Safety and Quality
Office of Technology Transfer

Moves Research Discoveries into the Marketplace

Robert Greisbach
Deputy Assistant Administrator

Three Sections:
Administrative and Partnership, Patenting and Licensing
Two Technology Transfer Tools

Cooperative Research and Development Agreements (CRADAs)

and

Small Business Innovation Research (SBIR) Grants
“Technological innovation is essential for fostering economic growth, enhancing global competitiveness, and protecting the environment.”
FOOD WASTE

Undersized or Blemished Produce

Convert to Puree and Process into Healthy Foods
Forming Technology for 100% Fruit Bars

5.5M bars sold equating to millions of pounds of fruit
15% of Wine Grape Production is Waste
120,000 tons per year in California
Modulation of the Intestinal Microbiota Is Associated with Lower Plasma Cholesterol and Weight Gain in Hamsters Fed Chardonnay Grape Seed Flour

Hyunsook Kim, Dong-Hyun Kim, Kun-ho Seo, Jung-Whan Chon, Seung-Yeol Nah, Glenn E. Bartley, Torey Arvis, Rebecca Lipson, and Wallace Yokoyama
“Never before in history has innovation offered promise of so much to so many in so short a time.”

Bill Gates
Bioproducts from Almond Shells & Hulls

Delilah F. Wood
de.wood@usda.gov
Almonds & Biomass

Eight Weeks

- Mesocarp (hull)
- Exocarp (hull surface)
- Endocarp (shell)
- Testa (seed coat)
- Seed (nut)
- Gum Ducts

Morrison et. al 1985 Botanical Gazette 146:15
Biomass Volume Increase
with Nut Tree Production Growth

US Tree Nut Biomass Production

Projected Almond Biomass

Raw Almond Shells

Biomass Heat Treatment

Makes biomass miscible with plastic

- Torrefaction: 200°C - 300°C
- Pyrolysis: 400°C
- Gasification: 900°C - 1000°C

Torrefied Biomass Increases Melt Temperature

Sun-Damaged Nursery Pots

Recycled PP + 15% TAS + 15% TYP

Heat Distortion Temperature
Torrefied Almond Shell as Additive to Recycled Plastics

+ Polypropylene + Polyethylene terephthalate (PET)

Material advantages of adding torrefied almond shells:
- Provides color, displacing carbon as pigment
- Increases tensile modulus, making the final product more rigid, a property often lost in recycled plastics
- Increases heat deflection temperature, meaning that the composite material is more heat-tolerant

Almond Hulls
Sugar Extraction

Total Sugars in Almond Hull

Percent Sugars in Hull

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total Sugars</th>
<th>Fermentable Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonpareil</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Butte</td>
<td>35%</td>
<td>25%</td>
</tr>
<tr>
<td>Padre</td>
<td>32%</td>
<td>22%</td>
</tr>
<tr>
<td>Carmel</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>Monterey</td>
<td>28%</td>
<td>18%</td>
</tr>
<tr>
<td>Fritz</td>
<td>26%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Sugar Types in Almond Hull

- Fermentable Sugars
- Total Sugars

Sugar Beets - 15-20% Sugar

Offeman et al., 2014, Industrial Crops and Products 54 (2014) 109-114
Peat – non renewable resource

Spent Almond Hulls
Hulls absorb 4-8 times weight of water

Button Mushrooms with Almond Hulls as Partial Peat Replacer

Thank you!

New Projects:

• Zero Waste Agricultural Processing
• Bioproducts and Biopolymers from Ag Feedstock
• Domestic Production of Natural Rubber and Resins
Food Loss and Waste: Innovations
Mushroom Stalks and Edible Straws

Tara H. McHugh
Center Director
USDA. Agricultural Research Service
Western Regional Research Center, Albany, CA
Innovative Mushroom Processing to Develop a Novel, Value-Added Source of Vitamin D
CHEMICAL CONVERSION

Ergosterol $\rightarrow_{UVB}^{\text{}\rightarrow_{UVB}^{\text{}}}$ Vitamin D2
Ultraviolet B Processing
Uvitron Unit
Ultraviolet Light Technology for Vitamin D Mushrooms - CRADA

Novel Ultraviolet B Process Being Used Nationwide on All Mushroom Varieties by #1 Mushroom Producer in U.S. Processes 250 millions pounds annually.
Novel Ultraviolet B Process To Treat Mushroom Waste
Remaining Question - Human Bioavailability?

Charles Stephensen
Acting Center Director
ARS, Western Human Nutrition Research Center
FOOD WASTE

Undersized or Blemished Produce

Convert to Puree and Process into Healthy Foods
Casting Technology
CRADA
Casting Technology for Fruit and Vegetable Edible Films

$8.5M Sales
Equating to consumption of over 15M servings of fruits and vegetables.
Edible Packaging Opportunities - Wraps and Straws

500M Straws Used Daily in U.S.
Prolonging Freshness with clamshells

Jinhe Bai, Xiuxiu Sun, Anne Plotto, Elizabeth Baldwin

Horticultural Research Laboratory
Fort Pierce, FL
Small fruit/berry food loss

Estimated over $3B in U.S. in 2018

Fresh market value $11B; Retail food loss 9.3% ($1B); Consumer food loss (kitchen) 19.4% ($2B)

Data from: USDA-NASS, 2018
Humidity is one of the key factors in fresh fruit preservation, which has been underestimated.

- In a CA system, preventing water loss has proved to be more important and cost-effective than controlling the gaseous environment (Ben-Yehoshua, 1989; Burg, 2004; Rodov et al., 2010).
- Apples (Lentz and Rooke, 1964) and bananas (Wardlaw and Leonard, 1940) lose water at a significant rate even when the relative humidity (RH) of the surrounding air is 100%.
- Many research reports describe the RH as 85-95%, implying that humidity is not a problem or that if greater than 85%, there is no problem. There is little data on whether there is the difference in produce response to RH of 90%-95% compared to 85% for example.

Adapted from Burg, S.P. 2004. Postharvest physiology and hypobaric storage of fresh produce. p240
Super simple technology – reduce perforation/openings

- The model was built based on mathematics/aerodynamics
- Field tests were run in > 10 fruits, > 10 years in three countries

Conclusion: Water loss in the commercial clamshells was 1.2–4.5-fold more than for the new clamshell
Several Reinforcements:

- Compostable packaging - adding citrus juice processing waste and other waste pectin to plastic polymers
- Antifog processing – prevent condensation caused contamination
- Combine packaging with controlled-release natural antimicrobial agents

Modified humidity clamshell

Commercial clamshell

Natural antimicrobial agents (controlled release)

Vents

Integrated packaging technology combining humidity control and slow release antimicrobials to prolong freshness and improve safety of small fruits and berries
### FRONT

<table>
<thead>
<tr>
<th>Position</th>
<th>Measure (cm)</th>
<th>Area (cm²)</th>
</tr>
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<tbody>
<tr>
<td>Lid</td>
<td>16.5 x 1.0</td>
<td>16.5</td>
</tr>
<tr>
<td>Bottom - upper</td>
<td>[(16.5+15.2)/2] x 3.5</td>
<td>55.475</td>
</tr>
<tr>
<td>Bottom - lower</td>
<td>[(15.2+12.5)/2] x 1.5</td>
<td>20.775</td>
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Gross outer surface area: 92.75 cm²

Aperture surface area: (0.55 x 0.55) x 2 = 0.605 cm²

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Gross outer surface area: 92.75 cm²

Aperture surface area: 0 cm²
THEMES

• 1. Sustainable Ag Intensification
• 2. Ag Climate Adaptation
• 3. Food and Nutrition Translation
• 4. Value-Added Innovations
• 5. Ag Science Policy Leadership
1st Objective

- Strengthen food processing, manufacturing, new uses and marketing through new technologies, innovation, and data analysis to create jobs and economic opportunities in rural America.