Traceability of Food and RFID

Dr. Ted Labuza
tplabuza@umn.edu

Fish, Deli, Coffee, Wine, Dairy, Cut Salad, Organics

Blood, Vaccine, Pharma, DoD Meals Ready to Eat, Film

Industrials
Paint
Adhesives
Solder
Paste
What do we want?

- Can we trace location of food in the distribution chain in case of an event (recall or bioterror)?
- Where did ingredients come from?
- What about the ingredients in ingredients?
- What line, batch #, date, time was it made on?

ISO 9000-2000 Clause 3.5.4 Traceability is the ability to trace the history or location of what is under consideration.
The long label

54 listed ingredients
What else do we want?  
Smart “Active” Labels

- Can we deliver consumer info (normal and handicapped)?
- Can we indicate shelf life left ie t-T history?
- Can we tell when food becomes unsafe?
  - Food poisoning cost the US >$7 billion in 2004
  - 73 MM illnesses 5000 deaths
- Can we detect dangerous agents with an active sensor label (nano-technology)?
US Drivers of Food Traceability

- Bioterrorism - intentional adulteration
-Recalls - food safety - unintentional adulteration
-GMO - international regulations
-Canadian BSE Cow
-Country of Origin Labeling
-Allergen labeling requirements
-Prescription drug management
-Logistics management & profitability (Wal-Mart)
Terrorism -> Bioterrorism

September 11, 2001

US News and World Report 12/24/01
Bioterror

- Intentional delivery of adulterant
- Early identification and traceability key to stopping before major damage
- Agriculture 1/6 of GDP 24 MM people
  - If 10% hit lose $9.6 billion/month

http://www.fda.gov/oc/bioterrorism/titleIII.html
One Hundred Seventh Congress of the United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Wednesday, the twenty-third day of January, two thousand and two

An Act

To improve the ability of the United States to prevent, prepare for, and respond to bioterrorism and other public health emergencies.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the “Public Health Security and Bioterrorism Preparedness and Response Act of 2002”.

(b) TABLE OF CONTENTS.—The table of contents of the Act is as follows:

Sec. 1. Short title; table of contents.

TITLE I—NATIONAL PREPAREDNESS FOR BIOTERRORISM AND OTHER PUBLIC HEALTH EMERGENCIES

Subtitle A—National Preparedness and Response Planning, Coordinating, and Reporting
TITLE III—PROTECTING SAFETY AND SECURITY OF FOOD AND DRUG SUPPLY

Subtitle A—Protection of Food Supply

Sec. 301. Food safety and security strategy.
Sec. 302. Protection against adulteration of food.
Sec. 303. Administrative detention.
Sec. 304. Debarment for repeated or serious food import violations.
Sec. 305. Registration of food facilities.
Sec. 306. Maintenance and inspection of records for foods.
Sec. 307. Prior notice of imported food shipments.
Sec. 308. Authority to mark articles refused admission into United States.
Sec. 309. Prohibition against port shopping.
Sec. 310. Notices to States regarding imported food.
Sec. 311. Grants to States for inspections.
Sec. 312. Surveillance and information grants and authorities.
Sec. 313. Surveillance of zoonotic diseases.
Sec. 314. Authority to commission other Federal officials to conduct inspections.
Sec. 315. Rule of construction.
FDA New Powers

- All processors must register facilities including foreign entities
  - Implemented by 12/12/03 (by law)
  - Pack, manufacture, process, or hold food
  - Exempts farms, transport, restaurants, retail
  - All food and feed ~420,000 facilities

- Holding girl scout cookies at home
Rutgers Food Policy Institute 9/26/03

- Survey of 1292 food industry personnel
- 50% unaware of new requirement
- Another 21% knew but no action taken
Food Section 307  Imports

http://www.fda.gov/oc/bioterrorism/titleIII.html
Imports

Food is 20% of all shipments = 8MM

200 K companies

40% fresh fruit

15% fresh veg
FDA Import Powers 10/9/03

- Importers must give prior notice of arrival at port of entry
- No more than 5 days prior
- No less than:
  - 2 hr by road
  - 4 hr by air or rail
  - 8 hr by water
- Submit electronically
- Began 12/12/03
- ~ 25,000 daily
- If inadequate or no info refusal of entry
- Est. cost $367 MM
Import Requirements

- Identify submitter
- Type of food
- Estimated quantity
- Manufacturer
- Grower
- Country of production
- Shipper and where shipped from
- Arrival time
- Identity of carrier
TITLE III—PROTECTING SAFETY AND SECURITY OF FOOD AND DRUG SUPPLY

Subtitle A—Protection of Food Supply

Sec. 301. Food safety and security strategy.
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http://www.fda.gov/oc/bioterrorism/titleIII.html
Covered Items

68 FR 25185-25240  May 9, 2003

- All foods
- All transporters
- All holders
- Some exemptions
- Keep 1 or 2 years depending on food
- Mandated March 2004
FDA is proposing to describe the specific information a covered entity must keep, but not specify the form or type of system in which those records must be maintained. Some of the provisions we are proposing include: …………

(3) requirements to establish and maintain records to trace the transportation of all food
Proposed requirements to establish and maintain records to trace the transportation of all food (§§ 1.351 and 1.352) would require that you keep records that trace the transportation process of all food you transport. The information that we propose as necessary to trace the transportation process includes: (1) The name, address, and phone number of the person who had the food immediately before you (the transporter’s immediate previous source), and the date you received it from that person; (2) the name, address, and phone number of the person who had the food immediately after you (the transporter’s immediate subsequent recipient), and the date you delivered it to that person; (3) the type of food transported; (4) the lot number or other identifier of the food if available; (5) the quantity; and (6) identification of each and every mode of transportation used (e.g., company truck, private carrier), received the food until the time you delivered it.

Food includes ingredients in food
Food Process Distribution Chain

FARM & Feed Ingredient supplier → Rail or truck → Distribution System eg silos → Process → supermarket → Distribution Center
5 day Lettuce orders

Goes to > 1000 stores
~ 1 million heads
Co-mingling at supermarket DC
The Fresh Milk System
According to comments received, firms exporting from the European Union (EU) are already subject to similar recordkeeping requirements under EU regulation 178/2002. Article 18: Traceability of the EU regulation states:

1. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures, which allow for this information to be made available to the competent authorities on demand.

3. Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.

(Ref. 14.)
Key Questions

• What is in the food, i.e., can we trace all ingredients?
• Where is it at and how much at any point in time?
  – Chain traceability - i.e., location info rather than ingredient info
• When will the product reach consumers?
  – Distribution (supply chain) and sales logistics
• How soon can/will the government react if they need to, i.e., data collection, transfer, and management systems?
  – Data is food movement and public health reports
Drivers

• Recalls
  – Majority are meat and allergens

News and Trends

Washington Watch

More Washington Watch articles

By J. Mark Huffman, Washington correspondent

Dairy Foods, April 2002
New Allergen Recall Regulations
Government food safety regulators are placing more responsibilities on processors for keeping consumers informed when problems occur. FDA has announced it will begin automatically classifying most allergen-related food recalls in the Class I category, requiring companies to notify the public. A Class I recall is one where “reasonable probability exists that the use of or exposure to a product will cause serious adverse health consequences or death.”

FDA’s Class I recall rule goes into effect when foods are not properly labeled that they contain one of the following allergens: peanuts, tree nuts, milk, eggs, soy, crustaceans, fish and wheat. These allergen categories, known as the Big Eight, make up 90% of all food allergies.

The International Ice Cream Association recently tackled the issue head on, presenting a roundtable for processors, led by Dr. Sue Hefle, University of Nebraska Food Allergy Research and Resource Program, and Dr. Kenneth Falcic of FDA. Processors were urged to develop a recall preparedness plan, mapping out clear communication channels with both the public and government officials.

Dairy processors have already implemented a number of programs to ensure precise labeling to inform consumers.
21 CFR Part 7

• Recall
  – To ensure removal of violative goods from interstate commerce
  – Not mandatory but if recall must follow mandatory procedure 21 CFR Part 7
  – FDA determines class based on seriousness
    • Class I - threat to life (now most allergens are so)
    • Class II - danger but no probable death
    • Class III - misbranding - no ill effects
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Meat traceability

- August 2002 19.8 MM lb hamburger recall
  - 30 ill with E coli O157:H7
  - 1 death
  - Only 8000 lbs back
  - Had a 3.5% rework policy
Recall Problem

• Not everyone aware of notice
• Not all food returned
  – Animal feed industry
  – Supermarket
  – home
Recall Problem

• GAO Report 11/04 “The time frames to do the recall exceeded the expected shelf life for some perishable foods that were recalled, such as ground beef and fresh-cut bagged lettuce” - note in 2003 USDA averaged 38 days and FDA averaged 31 days to complete recall verification.

Indicates the need for an electronic passive or active tag system that tells where food is or better publicity
Time to Event

# or symptoms

To Supermarket or broker

1st symptoms

Visit doctor

CDC-FDA Acts

Hospitalization

99% stopped

To DC

To Home

Days

0 1 2 3 4 5 10 12 15 20
Drivers GMO
GMO Starlink Incident

- Inadvertent mixing of regular corn with Cyr-9 protein from GMO corn
- Devastated farmers
EU labeling initiative 2003

- EU will accept US GMO if labeled with complete traceability to farm
- Label if \( \geq 0.1\% \) content
- US claims a trade barrier and files in WTO court
- US rep says “traceability not worthwhile” will lose $4 Billion in exports
- EU argues but same as FDA new powers
- C&E News 6/9/03 pg. 25-33
Drivers

• Canadian BSE Cow  May 2003

US, Canada to trace feed history of BSE infected cow

The Food and Drug Administration (FDA) has released a statement offering more details on the Canadian case of Mad Cow. Canada's government says that the brain of an eight-year old cow in a remote area of Alberta has tested positive for bovine spongiform encephalopathy.

According to Canadian officials, meat from the cow did not enter the food supply. The animal had been on the farm in Alberta for three years. Although BSE has not been shown to be transmitted among cows in a herd, as a precaution the herd in Alberta is being destroyed.

FDA is working closely with USDA, other US agencies, and the appropriate Canadian officials to gather additional information about this case, including previous owners of the cow and its location, as well as records concerning animal feed the cow ate.

FDA reminded that to date, no case of BSE has ever been found in the US, despite years of intensive testing for the disease.
In 2002 Canadian exports of beef were $4 billion
On first day (5/20/03) McDonalds lost $1.2 Billion in stock market
Canadian farm losses are $11 MM/day
Feedlot losses (1st month $400 MM)
in July $3.1 billion outstanding loans
August total loss $42 billion
GNP reduction ~1%
September - US allows some Canadian beef
  - < 30 months old
  - No rendered meat from cattle or other ruminants
  - Spinal cord and brain have been removed
How do we deal with GMO grain mixing at:
1. Silos
2. Trucks and trains
3. Processor silos

Indicates the need for an electronic active writeable tag system that records all and tells all
Drivers

• Country of Origin Labeling (COOL) 2003
Country of Origin Labeling

- Federal Security and Rural Investment Act of 2002 HR 2646 2002 (Farm Bill)
- COOL Sec 10816
- Identity required by 2004
- Retailer must ensure (indemnification)
- Fine $10,000 per violation
- 6/17/03 Japan asks 26 countries for beef traceability
- EU 104/2000 for fish
What happened?

• Pressure from commodity groups caused Congress to exempt all products except fish
COOL Outcome

• Under USDA jurisdiction -
  – will use discretion 1st year

• Only for fish/shellfish - 50% is imported
  – Country of origin and farm vs wild
  – Excludes if ingredient in processed food or fish
    is smoked, cured or cooked or for food service

• Went into effect 9/04 as interim final reg

• ERS estimates cost > $4 billion

• Rest delayed until 9/30/2006
Cool Record keeping

Country of Origin Labeling

Examples of records that may be useful for COOL verification purposes

The examples of documents and records listed in the attached tables, although extensive, are not inclusive of all documents and records that may be useful to verify compliance with the Country of Origin Labeling provisions of the 2002 Farm Bill. Additionally, maintaining documents and records such as those listed as examples will not necessarily ensure compliance. The documents listed are examples only and are for the sole purpose of providing information for producers, processors, and retailers to consider when establishing records for verification purposes. During a compliance audit conducted by USDA, auditors will review any and all documents to the extent necessary to arrive at an accurate decision on the level of compliance.

- Cattle, Beef, Muscle Cuts of Beef, Ground Beef - PDF file
- Farm-Raised Fish - PDF file
- NEW Farm-Raised Shellfish - PDF file
- Hogs, Pork, Muscle Cuts of Pork, Ground Pork - PDF file
- Peanuts - PDF file
- Perishable Agricultural Commodity - PDF file
- Sheep, Lamb, Muscle Cuts of Lamb, Ground Lamb - PDF file
- Wild Fish - PDF file

http://www.ams.usda.gov/COOL/
Food Allergen and Consumer Protection Act 8/3/04

- Title II S741
- Requires all allergens to be declared including hidden
- Identity in common language use 8 major food categories
- Report to Congress on allergen inspections and methods to reduce contact
- Guidelines for restaurants and food service to prepare allergen free foods
- Investigate the “may contain” label
- Takes effect 1/1/2006

Indicates the need for an electronic active tag system that records and forwards info to next step
Achieving Traceability

- Tag-reader compatibility
  - frequency
  - EDI
- Data standardization ePC
- Traceable resource unit (TRU)
  - One fish vs 1 case vs 1 pallet
The start of RFID

- Wal-Mart
  - 2004 sold $1.7 billion retail out of $7.5 billion total (22%)
  - Required top 100 suppliers to use RFID by 1/1/05
  - All suppliers required by 2006
  - Already shows that RFID helps reduce inventory requirements and out of stock situations
- 2004 Retailers worldwide spent $400 MM on RFID
  - High costs limits RFID to retailers with >$5 billion sales
- Military to switch by 2006
- RFID manufacturers in 2005 release new tags at < 10 ¢ (Avery Dennison and Alien)
- US will adopt EU ISO standards
- Frost & Sullivan predicts >$4 billion RFID sales by 2011
Expiration Dating of foods - the next step?????

The last quart of milk you sold me was no good !!!

Did the date expire

No, but the cat I gave it to did

DAIRY

Question of safety vs food quality
Shelf Life Dating

- OTA Study on Open Shelf Life Dating of Foods 1979-81
  - Open dating is state driven (~30 in 2002)
  - No federal requirements on food but required on drugs, OTC and infant formula
  - Open shelf life dating of foods is desirable
  - Open date compromised if temperature abused
Types of food dating

- Code date
- Born on date
- Sell by date
- Better if used by
- Freeze by
- Best when purchased by
- Best if used by - minimum durability
- Death date - use by (expiration)
Sensory Shelf Life of Specialty Skim Milk

Temperature °C

Hours

2x10^2 CFU/mL
3x10^2 CFU/mL
2x10^4 CFU/mL
4x10^7 CFU/mL
8x10^4 CFU/mL

Q_{10} \sim 5

MN-SD Dairy Research Center
“Manufacturers will still remain dependant on good refrigeration and safe handling by truckers and supermarket employees. Ted Labuza, professor of food science and engineering at the U of M, has designed a special “tell the truth” tape that records a food’s “time-temperature history” and turns a darker gray when the food is spoiled.”
Chemical Tag Design parameters

• TTI - time-temperature integrating tag
  – Chemistry of reaction in tag follows food or drug kinetics
  – Rate of degradation as f(T)
    • Arrhenius function
    • Similar $E_a$ or $Q_{10}$

$$k = k_o e^{-\frac{E_a}{RT}}$$

$$\ln k = \ln k_o - \frac{E_a}{RT}$$

or $\ln \tau = \tau_r - bT$
Shelf Life plots food or drug vs tag

Illustration of proper and improper TTI design
Design parameters for TTI tag

• Need chemical reaction with same temperature sensitivity

• Need Distinct point for run-out time
  • Better to be sharp or sorting problem
Lifelines acetylenic monomer tag polymerization catalyzed by Pt
Vaccine Vial Monitor (VVM)

- WHO mandated programs for health care and food safety.
  - Vaccine Vial Monitors mandated by World Health Organization and UNICEF
  - ISO 9001.2000 and HACCP
- Sold > 120 million “Heatmarker” labels for polio VVM (100% of WHO requirement)
3M Commercial Tests of Monitor-Mark

CUB Foods

Johnsonville Brats
• FIFO vs LSFO system (Wells and Singh)

• Taoukis et al ≥15% savings (EU FAIR)
  – Case study with fish

• http://www.vitsab.com/htdocs/default.htm
FISH SENSORY TEST
ISOTHERMAL STORAGE

Sensory evaluation- Air packed seabream

Giltheaded Seabream (Sparus Aurata) shelf life kinetics
TEMPERATURE DEPENDENCE OF FISH SHELF LIFE

Giltheaded Seabream (*Sparus Aurata*) - Arrhenius plot

\[ y = -8877.9x + 5.0216 \]
\[ R^2 = 0.9906 \]

<table>
<thead>
<tr>
<th>SL₀ (hr)</th>
<th>( E_a ) (kcal/mol)</th>
<th>( R^2 )</th>
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</thead>
<tbody>
<tr>
<td>170-200</td>
<td>17.8</td>
<td>0.99</td>
</tr>
</tbody>
</table>
FISH SENSORY TEST: NON-ISOTHERMAL STORAGE

VARIABLE TEMPERATURE VALIDATION

\[ T_1 = 0^\circ\text{C},\ 5h\ -\ T_2 = 8^\circ\text{C},\ 3h\ -\ T_3 = 15^\circ\text{C},\ 2h \Rightarrow Teff = 6.55^\circ\text{C} \]

Air packed: Experimental shelf life = 69 h
Predicted shelf life = 71 h (68-74)

*Sparus aurata* shelf life kinetics-
Application in dynamic conditions shows no history effect
Field Test: Monitoring seabream exported from Greece to Italy

1. Chios island
2. Piraeus port
3. Patra port
4. Italy
5. Local consumers
6. Retail outlet

Measurement of TTI on top of boxes:
- (27 h)
- (48 h)
- (59 h)
- (68 h)
- (78 h)

Measurement of TTI inside the boxes:
- (33 h)
- (59 h)
- (68 h)

External TTI expiration:
- (101 h)
- (120 h)
% Life Consumed

<table>
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<th>Time (h)</th>
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<td></td>
<td>out</td>
<td>Inside box</td>
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<tr>
<td>48</td>
<td>60%</td>
<td>40%</td>
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<tr>
<td>78</td>
<td>85%</td>
<td>50%</td>
</tr>
<tr>
<td>120</td>
<td>&gt;100%</td>
<td>90%</td>
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</table>

Field Test: Monitoring seabream exported from Greece to Italy

Note test showed if use LSFO increase profit by 15%
Ship based on least shelf life left (LSFO)
JFS 68(1):201-9
J Food Protection 64(7): 1051-57
Reduction in illness using LSFO
Commercial Application Problems

• Don’t want to know about problem
• Liability if tied to safety
• Marketer’s resistance to cost
• BUT!!!! Tracing with time-temperature logging is insurance policy and gets “who did it”

So portable active “data loggers”
Driving sectors
Active “RFID Labels” for t-T management

- includes
  - Foods $4 billion
  - Cut flowers - potential $58 MM global
  - Drugs DOD study on dates
  - Mail order/web drugs
  - Adhesives
  - Photographic film
  - Cosmetics
  - Explosives
  - Paint

Walmart sets date for RFID adoption
One hundred key suppliers to tag pallets by 2005

Walmart Stores Inc. will roll out an RFID-based pallet-tracking system by 2005, a move that will force the hand of other retailers and consumer packaged goods manufacturers that have waffled on rolling out the technology. In a standing-room-only presentation at last week’s Retail Systems conference in Chicago, CFO and senior vice president Linda Dillman outlined the world’s largest retailer’s implementation roadmap for RFID, and issued a challenge to the technology provider community to help overcome the obstacles to widespread adoption.

“We believe very strongly in the potential of this technology to do wonderful things for our customers and suppliers,” Dillman says, noting that Walmart has opened an RFID lab in Enmore, Ark., and has
Reymomsis Fish Shelf Life Data Logger Integrator

For fresh fish
Logistics management and Profitability ECR

Hughes GeoStar GPS Satellite delivery control
Data loggers

- Reusable
- $10-$15 cost
- Designed for distribution system
Sensitech Logistics and Temperature Management

How Information is Converted Into Power.

1. **Shipping Location**
   - At the shipping location, TempTale monitors are added to the shipment. At that time, all customized logistic information can be transmitted to the secure database.

2. **Receiving Location**
   - Monitors are checked for out-of-range conditions and can be downloaded for complete trip history. All trip information will be forwarded to the central database.

3. **Central Location**
   - Information is stored at the central site and can be accessed by the customer in various electronic or web-enabled formats.

4. **Customer**
   - The customer can use the power of their information to solve problems throughout their supply chain.

[http://www.sensitech.com/h_index.html](http://www.sensitech.com/h_index.html)
### Determination of Effect of Time/temperature Distribution on Shelf Life or quality loss

**Product Name**: Salmon Shelf Life

**Reference**: 

Data limited to three temperatures

Input the initial and final quality values (cannot be zero for 1st order) for most foods use As = 2

**Define**:
- Initial Quality Ao = 100
- End Value As = 2

Note a key here is what you choose as an endpoint

This should be discussed with an Infratab scientist

Input the temperature and shelf life time

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<th>Temp °C</th>
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**Kinetic parameters**

- **Shelf life equation**: \( t_s = t_0 \exp(-bT) \)
- **Rate increase for a 10°C increase in temperature**: \( r_2 = 0.98 \)
- **Slope of shelf life plot**: \( b = 0.14 \)
- **Shelf life at T = 0°C**: \( t_0 = 248.18 \) kcal/mole

**Zero order**
- **Preexponent of \( k \)**: \( \text{Ea} = 20.82 \) kcal/mole
- **Zero order preexponent of \( k \)**: \( \text{ko} = 1.82E+16 \)

**First order**
- **Preexponent of \( k \)**: \( \text{Ea} = 20.82 \) Kcal/mole
- **First order preexponent of \( k \)**: \( \text{ko} = 7.28E+14 \)
- **Rate constant**: \( r_2 = 1.00 \)

**Inverse Temperature**

**Log rate constant**

**Temperature**

**Arrhenius Plot**

**Shelf Life Plot**
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**Quality Lost zero Order**

- 110 days

**Quality Loss First Order**

- 130 days

Value (Y) Axis Major Gridlines
iButton

- Thermistor (-40 °C to +80°C) in Δ 0.5 C
- Clock/calendar (seconds up to years) @ ± 1 min/month
- Thermal history logger ~ 1 million points
- Extra memory for manifest
- Cost $2 to $53
Freshloc

t/T and t/°RH logging

How FreshLoc Works

The FreshLoc system is based upon tiny wireless sensors (shown here) that transmit continuously. It automatically and continually collects data such as temperature, humidity and other measures via a unique secure Internet connection.

In a given facility, FreshLoc sensors are arrayed and transmit wirelessly (for up to hundreds of feet) to a small reader / receiver which is connected to a gateway device allowing Internet connection.

With Internet connection, data is available for alerting and reporting via pager, fax, phone or email.

What Is Freshloc?

Dec. 13, 2002 – 7-Eleven Installs FreshLoc Technology in Combined Distribution Center for 692 Southern California Stores To ensure the freshness and quality of its fresh food and sandwich offerings, 7-Eleven, Inc. (NYSE:SE) is installing Cold Chain Control™ technology, a wireless, automatic monitoring system from FreshLoc Technologies (www.freshloc.com), in the Combined Distribution Center located in Fullerton, Calif. 7-Eleven aims to increase fresh food sales nationwide over the next five years. Cold Chain Control technology from FreshLoc helps to manage safe temperatures from a single distribution facility that serves Los Angeles/San Diego-area 7-Eleven stores.

http://www.freshloc.com/
Next generation Electronic “Smart Labels” for TTI

• Driven by
  – Poor performance/acceptability of chemical tags
  – No data storage to find weak link (insurance)
  – Electronics got smaller
  – Move towards electronic tags with RFID to replace bar codes with traceability
  – Can build in run out time and activation energy on computer chip so kinetics match is easy to do
  – Can create sharp end point
  – Electronics does not have history effect
  – Includes traceability at same time (RFID)
  – Ability to follow multiple steps with different Ea (microbes)
Microbial Life cycle

- Lag phase
- Exponential phase
- Stationary phase
- Death phase

Each has a different temperature sensitivity

CFU critical

log N

Below detection

CFU limit

$t_0$

$t_{TTD}$

$t_{Lag}$

N0

CFU limit

Each has a different temperature sensitivity

...
Listeria Shelf Life (100 CFU/g) on hotdogs

t = 149.69e^{-0.1176 T}
R^2 = 0.9385
Factors

• Temperature sensing
  – Thermocouple
  – Themistor
  – Temperature sensitive Quartz crystal
• Location of tag (outside or inside)
• Energy use - power drain - battery
• Chip size and cost (bits limit)
• Antenna size and attachment
• Flexible so on roll stock
• Ruggedness in environment
• Software and compatibility
To verify the temperature conditions during complex logistic processes a unique identification of the product and a low cost documentation of the temperature curve during transportation and storage is necessary. Especially nowadays where most companies receive and send international deliveries, a well documented quality of the shipped product is a major business advantage. The TempSense® label from KSW offers you not only the documentation of the temperature curve, it also determines for you if the product has been exposed too long to a certain temperature. TempSense® documents exceptions in the storage temperature and tells you when and for how long the product was exposed to a certain temperature. Only with these data a high quality of chilled and frozen products can be proved.
Micro-electronic TTI tag vendors

• Technopuce (France)
  – Acti-Tag  RFID TTI for t/T integration
  – Hemo-Tag TTI for blood (two technology awards)
  – http://www.technopuce.com/
Micro-electronic TTI tag vendors

- **Infratab (US) skaye@infratab.com**
  - Micro-electronic TTI integrator
    - RFID capability for traceability
    - US Patent # 5,442,669
  - For food and other perishables
  - Prototype design stage
    - T sensitive quartz clock
    - Look up table to replace exponential function
    - Clock reads T at 15 min intervals
End points

- Color change
- Lights up red
- Beeps
- LED - don’t use
- Or if listeria then blows up food
Critical Factor - Cost

- GPS - $75-300
- Real-time locating sys. (RTLS) $20-100
- Two-way active RFID – GTAG $5-$25
- Active beacon RFID $1.25-$5.00
- Semi-Active RFID $.50-5.00
- Short range passive RFID $.15-.50
- Very short range passive RFID $.02-.06 (EAS)
- Bar code - $.001

Level of Automation

Manual entry

Device Cost ($)
Critical Factor - technology

- Choice of frequency ISO standards
- Data standards ePC
- Water absorption of μ-wave reduces power
- Reflectivity of metal
- Standards for readers
- Software compatibility
- Data security
Use concerns

- Influence of environment on tag
- Recycling prohibitions if on primary package
- Environmental disposal (EPA)
  - Heavy metals in battery
  - Organics
Traceability concerns

- 4th amendment rights of privacy
- Cost of implementing RFID vs paper files
- Pallets vs cases vs packages (TRU)
- Tag reliability in environment
- Standards for data security during collection, management and sending
- KISS software
- Palm compatibility
That’s all folks
Contact

Dr. Theodore Labuza
Department of Food Science and Nutrition
University of Minnesota
tplabuza@umn.edu
612-624-9701 fax 651-483-3302 cell 651-307-2985
http://che.faculty.umn.edu/Ted_Labuza/tpl.html