Foodborne Illnesses: Issues and Answers

Michael Doyle

CFS
UGA CENTER FOR FOOD SAFETY
College of Agricultural and Environmental Sciences

Foodborne Illnesses: Issues and Answers

- USA foodborne illnesses trends
- Sources of foodborne pathogens
- Food safety issues with aquaculture
- Antimicrobial resistance
- Food safety issues with food ingredients

Foodborne Illnesses: Issues and Answers

- Economically-motivated food adulteration
- Consumer use of foods with unintended consequences
- Future trends in food production

U.S. Foodborne Disease Surveillance System

- CDC and State Public Health Departments identify today many outbreaks that would have been undetected 5 - 10 years ago
- CDC monitoring ca. **20 - 40 outbreak** clusters **daily**
- **1200 to 1500** foodborne disease **outbreaks** are now reported **annually**

Examples of Foods Not Previously Associated with Foodborne Outbreaks Until 2006 - 2013

- **Bagged spinach (*E. coli* O157:H7)**
- **Pasteurized carrot juice (Botulism)**
- **Peanut butter (*Salmonella*)**
- **Puff rice and corn snack food/dried imported vegetable seasoning (*Salmonella*)**
- **Peanut paste (*Salmonella*)**
- **Cookie dough (*E. coli* O157:H7)**
- **White and black ground pepper (*Salmonella*)**
- **Jalapeño peppers (*Salmonella*)**
- **Turkish pine nuts (*Salmonella*)**
- **Pistachios (*Salmonella*)**
- **Hazelnuts (*E. coli* O157:H7)**
- **Bagged organic spinach and Spring mix (*E. coli* O157:H7)**
- **Pomegranate seeds (Hepatitis A)**
- **Bagged salad mix (lettuce, cabbage, carrots) (*Cyclospora*)**

Foodborne Disease Outbreaks Attributed to a Single Commodity by Leading Food Vehicles, 2006-2010

Year	Rank	Food Vehicle	% of Outbreaks
2006	**1**	**Produce**	**24**
	2	Meat	19
	2	Fish and Shellfish	19
	4	Poultry	14
2007	1	Meat	23
	2	**Produce**	**21**
	3	Poultry	17
	3	Fish and Shellfish	17

CDC, MMWR 58:609-615 (2009)
MMWR 59:573-979 (2010)
MMWR 60:1197-1202 (2011)
MMWR 62: 41-47 (2013)

Foodborne Disease Outbreaks Attributed to a Single Commodity by Leading Food Vehicles, 2006-2010

Year	Rank	Food Vehicle	% of Outbreaks
2008	**1**	**Produce**	**28**
	2	Meat	23
	3	Poultry	15
	4	Fish and Shellfish	14
2009 - 2010	**1**	**Produce**	**28**
	2	Meat	24
	3	Fish and Shellfish	20
	4	Dairy	12

Attrition of Foodborne Illnesses and Deaths to Food Commodities (U.S. Outbreak Data 1998 - 2008)

Commodity	% Illnesses	% Deaths
Produce	**46**	**23**
Leafy (lettuce, spinach, etc.)	**22**	6
Fruits - nuts	12	7
Vine - stalk	7.9	7
Root	3.6	1.4

J. A. Painter et al. Emerg. Infect. Dis. 19:407-415 (2013)

Sources of Foodborne Pathogens

- Many foodborne bacterial pathogens are carried asymptomatically in the gastrointestinal tract of a variety of animals
  - *Salmonella*
  - *Campylobacter*
  - Enterohemorrhagic *E. coli* (e.g., *E. coli* O157:H7)
- These pathogens are shed by animals (and infected humans) in feces

Examples of Human Pathogens Associated with Animals/Raw Milk

- Raw milk (no bactericidal/bacteriostatic treatment, apart from cooling) is a vehicle for transmission of pathogens, such as:
  - *Listeria monocytogenes*
  - *Brucella* spp.
  - *E. coli* O157:H7 and non-O157 EHEC
  - *Campylobacter* spp.
  - *Mycobacterium bovis* and *Mycobacterium tuberculosis*
  - *Coxiella burnetti*
  - *Salmonella* spp.
  - *Yersinia enterocolitica*

The Manure Glut: A Growing Environmental Threat

- Livestock and poultry produced an estimated 1.11 billion tons of manure in the U.S. in 2007
  - 80% is produced by cattle
- ca. 3.5 tons of animal manure is produced annually nationwide for every person living in the United States

U.S. Environmental Protection Agency, July 2013, Literature Review of Contaminants in Livestock and Poultry Manure and Implications for Water Quality

Percentage of Great Britain Livestock Manures Contaminated with Zoonotic Microbes

	Cattle		Swine		Poultry		Sheep	
Pathogen	Fresh[a]	Stored[b]	Fresh	Stored	Fresh	Stored	Fresh	Stored
E. coli O157:H7	13.2	9.1	11.9	15.5	ND[c]	ND	20.8	22.2
Salmonella	7.7	10.0	7.9	5.2	17.9	11.5	8.3	11.1
Campylobacter	12.8	9.8	13.5	10.3	19.4	7.7	20.8	11.1

[a] Fresh, collected from location in which deposited

[b] Stored, collected from lagoon or farm yard manure heap

[c] ND, not determined

M. L. Hutchison et al. Lett. Appl. Microbiol. 39:207-214 (2004)

Milk Contamination

- Animals shed bacteria into milk
  - Mastitis
  - Bacteria living on teat
- Milk or equipment contaminated with animal feces

Environmental Contaminants in Milk Production

Sources of pathogens:

- Fecal contamination
  - Soil
  - Water
  - Cattle hide, tail, udder, teats
  - Pests (e.g., mice, flies)

Pests + Foods =

Public Outrage + Food Safety Recalls

The successful prosecution of Tesco for food safety violations at its Covent Garden Tesco Metro store has snowballed into a PR nightmare for the retailer in what has been dubbed the ‘supermouse’ incident.

Tesco's "Supermouse" Incident (July 2013)

- PR nightmare for Tesco
- Found guilty in Southwark Crown Court (London) of failing to:
  1. Keep the premises clean
  2. Have adequate procedures in place to control pests
  3. Keep raw materials and ingredients in appropriate conditions
  4. Keep wrapping materials stored in proper manner
  5. Have a proper layout, design and construction of food premises to protect against contamination
  6. Implement and maintain proper HACCP procedures

  *Each count carried maximum fine of £5000 ($8000 US)
- Tesco pleaded guilty to the six offenses and issued an apology

Pests as Sources of Foodborne Pathogens

- Insects
- Rodents
- Birds

Insects

- Insects (such as houseflies, ants and cockroaches) pick up pathogens (such as *Salmonella*, *E. coli* O157, and *Campylobacter*) on their mouthparts and tarsi
  - Sources of pathogens include human and animal feces, raw meat and poultry, stagnant water
    - Example, *Campylobacter* isolated from 51, 43 and 9% of **flies** on poultry, swine and dairy farms, respectively
  - Carry pathogens to RTE foods from feces, meat, etc.

Rodents

- Rodents (such as mice and rats) carry pathogens (such as *Salmonella* and *Campylobacter*) in their intestinal tract and transmit pathogens through their feces, saliva and tarsi
  - Examples, 4 - 7% of house mice in poultry houses were positive for *Salmonella*, and 11% of rodents (mostly mice) in dairy farms were positive for *Campylobacter*

Birds

- Birds (such as sparrows and pigeons) carry pathogens (such as *Salmonella* and *Campylobacter*) in their intestinal tract and transmit pathogens through their feces
  - Examples, 38% of farm sparrows and 40% of urban sparrows were positive for *Campylobacter*

U.S. Food and Drug Administration's "Dirty 22"

- FDA recognizes rodents, flies and cockroaches as contributing factors to the spread of foodborne pathogens
- FDA's "Dirty 22" are the 22 most common pests the agency recognizes in contributing to spreading foodborne pathogens

Y. L. Jones et al. J. Food Prot. 76:144-149 (2013)

U.S. Food and Drug Administration's "Dirty 22"

German cockroach
Brown band cockroach
Oriental cockroach
American cockroach
Pharaoh ant
Thief ant
House fly
Stable fly
Little house fly
Latrine fly
Cosmopolitan blue bottle fly
Holarctic blue bottle fly
Oriental latrine fly
Secondary screw worm
Blue bottle fly
Green bottle fly
Black blow fly
Red-tailed flesh fly
House mouse
Polynesian rat
Norway rat
Roof rat

Y. L. Jones et al. J. Food Prot. 76:144-149 (2013)

U.S. Food and Drug Administration's "Dirty 22"

- Flies, ants and cockroaches breed and feed in animal manure and human feces, and have transferred human pathogens on their mouth parts, body, leg hairs and feet
  - Pathogens include *Shigella*, *Salmonella*, *Campylobacter jejuni*, *E. coli*, *Vibrio cholerae*
  - Because filth flies have clustering and swarming behaviors at sites of attraction such as food sites, the high density of flies proportionally increases pathogens on surfaces frequented by the flies
- **Agency considers food adulterated in contact with any of these common pests; results in product recalls**

Y. L. Jones et al. J. Food Prot. 76:144-149 (2013)

The Hazards of Drinking Raw Milk and Eating Unpasteurized Dairy Products

- Eating dairy products made from unpasteurized milk and drinking raw milk is **150 times** more likely to cause foodborne illness outbreaks than pasteurized milk
  - Such outbreaks had a hospitalization rate **13 times** higher than those involving pasteurized dairy products
  - 121 outbreaks caused by dairy products between 1993 - 2006
    - 60% were caused by raw milk and 39% by pasteurized milk products
    - Less than 1% of milk consumed in USA is raw

Langer et al. (US CDC) Emerg. Infect. Dis. Mar 2012

Food Safety Issues Associated with Aquaculture

Primary Sources of U.S. Imported Fish and Seafood in 2005

- **Shrimp**: ca. **1.1 billion pounds**
  - Thailand, Ecuador, Indonesia, China, Vietnam, India
- **Salmon**: ca. **480 million pounds**
  - Canada and Chile account for ca. 90% of all Atlantic salmon imports
- **Tilapia**: ca. **300 million pounds**
  - China, Taiwan, Ecuador

USDA, ERS , Aquaculture Outlook, October 2005

Predicted U.S. Fish and Shellfish Import Trends

- Gains in seafood production will primarily come from farmed fish
  - **Aquaculture** accounted for 12% in 1984 and **50%** in **2009**; **predicted 62%** in **2030**
- **Tilapia** consumption will **exceed salmon** consumption in USA in **2014**
  - ca. 70% of tilapia is imported from China

Fecal Waste Used in Aquaculture Production

- Raw domestic sewage and/or livestock manure are frequently used in fish farming in many Asian countries
  - Estimates at least two-thirds of the world production of farmed fish is grown in ponds fertilized with animal manure or human sewage
    - ca. 50% of fish and seafood is raised in ponds

Chicken/Shrimp Farming in Thailand

- Chicken/shrimp farming is only means of income for many small stakeholders
  - Chicken coops (e.g., 20,000 birds/farm) sit in rows suspended over ponds that hold shrimp
  - **Fecal waste from chickens is primary nutrients for pond flora on which shrimp feed**

BBC News, January 27, 2004


AP

Examples of Prevalence of Salmonella in Seafood and Fish

Species	Country of Origin	Prevalence (%)
Seafood	Raw Imported (FDA surveillance; 1990-98)	**10**
	Raw Domestic (USA) (FDA surveillance; 1990-98)	2.8
	RTE Imported (e.g., cooked shrimp; 1990-98)	2.6
	Vietnam (1990-98)	30
Shrimp	Vietnam (2005)	**24.5**
	India (2003-2007)	**5 - 59**
Fish	Raw Imported (FDA surveillance; 1990-98)	**12.2**

J. Food Protect. 63:579-92 (2000)

Food Control 21:343-61 (2010)

Antibiotic Contaminants from Vietnamese Shrimp Farming

- Antibiotics are commonly administered in shrimp ponds as medicated feed, injection or a topical bath
  - Antibiotics leach from feed pellets into pond water before pellets are consumed
  - 60 to 85% of a drug is excreted in feces of shrimp without modification
    - 95% of oxytetracycline passes through shrimp and is released in the environment
- **Deposition of antibiotics from uneaten feed or feces are major routes of environmental contamination in aquaculture**

H. T. T. Thuy et al. Environ. Sci. Pollut. Res. 18:835-841 (2011)

Antibiotic Contaminants from Vietnamese Shrimp Farming

- **Ciprofloxacin** (500 mg) and **oxytetracycline** are used extensively (almost 100%) in Vietnamese shrimp farming to **kill** or inhibit the growth of **shrimp disease-causing bacteria** (e.g., *Vibrio*, *Pseudomonas*, *Aeromonas*) during shrimp larvae rearing
  - Extensive use of antibiotics has led to **high levels of residues in shrimp ponds** and the **surrounding environment,** with the resulting **proliferation of drug-resistant bacteria**

H. T. T. Thuy et al. Environ. Sci. Pollut. Res. 18:835-841 (2011)

Multidrug-resistant *Salmonella* in China

- "Multidrug-resistant *Salmonella* of animal original constitute an even more serious problem in China than in developed countries of the world."
  - Cui et al. J. Antimicrob. Chemother. 63:87-94 (2009)
  - Xia et al. J. Clin. Microbiol. 47:401-409 (2009)
- "Findings . . . indicate that **multidrug-resistant *Salmonella*** now **contaminate 67% of domestic animals in China**, with **some strains resistant to 17 different antimicrobial agents**."
  - Chen et al. Chin. J. Vet. Med. 44:6-9 (2008)

Lu et al. Foodborne Pathogens and Disease 8:45-53 (2011)

Antibiotic-resistant Microbes in China

- "The situation with respect to overuse of antibiotics and antibiotic resistance in China is severe."
  - Reynolds et al. Health Policy (2008)
- "**China** has the **world's most rapid growth rate of resistance**" (**22%** average **growth** in a study spanning 1994 to 2000)
  - Zhang et al. Global Health 2:6 (2006)

Antibiotic Resistance Issue

- Many critical antibiotics for human therapy are becoming less effective/useful
- Need to restrict use, but prudently
- Complex problem with no simple solution(s); solutions are complex
  - Ban of their use in agriculture has led to some unintended adverse consequences
- Global problem that cannot be solved by USA and/or EU alone; need global commitment and involvement
  - **Global travel**
  - **Food imports**

Food Safety **Chemical Issues** Associated with Foods Produced in China

- Farmers rely on **heavy use of chemicals** to deal with **pest** pressures, and **antibiotics** are widely used to control **disease in livestock, poultry and aquaculture**
  - Use many **highly toxic pesticides**, including some that are banned in the USA
  - Farm chemicals are sometimes **mislabeled and inappropriately used**
  - Some farmers have **little understanding of correct** chemical **use**, resulting in excessive residues in harvested product

USDA-ERS www.ers.usda.gov/AmberWaves/November08/Features/FoodSafety.htm

Food Safety **Chemical/Microbiological Issues** Associated with Foods Produced in China

- **Industrialization and lax environment controls** contribute to **heavy metal contamination** of foods
- **Untreated human and animal wastes** are applied to **fields** directly and through contaminated **irrigation water**

USDA-ERS www.ers.usda.gov/AmberWaves/November08/Features/FoodSafety.htm

Pathogen Contamination of Sensitive Food Ingredients

Examples of Sensitive (RTE without additional microbial kill step) Ingredients

- Low-moisture, high-fat
  - Peanut/nut butter/paste
  - Chocolate
  - Nuts
- **Spices**, herbs
- Flour (raw)
- Vitamins
- Calcium carbonate
- Soy protein isolate

Characteristics of *Salmonella* in Association with Low-moisture and High-fat Foods

- *Salmonella*
  - Can **survive for months to years** in **low-moisture foods** such as peanut butter, chocolate, non-fat dry milk, dried spices
  - **Small number** of this bacterium can **produce illness** when consumed in **high-fat foods** such as chocolate (< 1 *Salmonella*/g), peanut butter, paprika-coated potato chips

High Fat Content of Food Influences Infectious Dose

- High fat content of chocolate (cocoa butter), cheese (milk fat), and meat (animal fat) is common factor among foods associated with low infectious dose
- Entrapment of salmonellae within hydrophobic lipid micelles affords protection against the bactericidal action of gastric acidity
- Rapid emptying of gastric contents could also provide alternate mechanism

Human infectious dose of *Salmonella*

Food	Serovar	Infectious Dose (CFU) *
Eggnog	Meleagridis	10^4 - 10^7
	Anatum	10^5 - 10^7
Imitation Ice Cream	Typhimurium	10^4
Chocolate	Eastbourne	**10^2**
Hamburger	Newport	**10^1 – 10^2**
Cheddar Cheese	Heidelberg	**10^2**
Chocolate	Napoli	**10^1 – 10^2**
Cheddar Cheese	Typhimurium	**10^0 - 10^1**
Chocolate	Typhimurium	**≤ 10^1**
Alfalfa Sprouts	Newport	**< 4.6 X 10^2**
Ice Cream	Enteritidis	**< 2.8 X 10^1**
Paprika Potato Chips	Saintpaul	**4 X 10^0 – 4.5 X 10^1**
	Rubislaw	
	Javiana	

***** Number of *Salmonella* detected in foods associated with an outbreak

Foods Containing Sensitive Ingredients of Increased Public Health Concern

- Sensitive ingredient applied to food product after pathogen-kill step and food is ready-to-eat
  - Examples, spice or seasoning applied to potato chips, puffed snacks or nutrition bar
- Sensitive ingredient applied to fatty foods that do not receive *Salmonella*-kill step
  - Examples, pepper applied to salami, paprika-seasoned potato chips
- Spices applied to foods for high-risk populations
  - Example, foods served in nursing homes

Examples of prevalence of *Salmonella* in sensitive ingredients

Ingredient	Source	*Salmonella*-prevalence	Year
Raw Flour	USA	1 - 2%	1989, 2011
Raw, Shelled Peanuts	USA	2.3% (<0.03 - 2.4 MPN/g)	2008 - 2010
Spices	Imported into USA	6.6%	2007 - 2009
Spices subjected to pathogen-kill treatment	Imported into USA	3.0%	2007 - 2009

Spice Imports into the USA

- **8 countries** account for ca. **75%** of **spices** imported into USA
  - **India, Indonesia, China, Brazil, Peru, Madagascar, Mexico and Vietnam**
  - **Indonesia and India account for ca. 50%**

Salmonella Montevideo Outbreak Associated with Black or Red Pepper-Coated Salami

- 272 cases of *S*. Montevideo infections in 44 states in April 2010
- Associated with Daniele International's pepper-coated salami and sausage products
- **Pepper (black or red)** coating the salami/sausage was source of *S*. Montevideo
  - Contaminated Asian-grown pepper was supplied by two different international suppliers

Prevalence of *Salmonella* in Spices in USA (2001 – 2005)

- 310 ***Salmonella*-positives** of 3,131 samples **(10%)**
  - Examples of contaminated products: basil, black pepper, white pepper, chili pepper, chili powder, celery seed, cumin, sage, oregano, nutmeg
  - 59 of 329 **(18%) sesame products** were ***Salmonella*-positive**

S. Madron, C. Keys, and A. Datta, U.S. Food and Drug Administration

Prevalence of *Salmonella* in Imported Spices to USA, FY 2007 - FY 2009

	Salmonella-positive	
Spice	No. pos./No. sampled	Prevalence (%)
Coriander	16 / 110	15
Oregano/Basil	10 / 82	12
Sesame seed	20 / 177	11
Curry powder	17 / 195	8.7
Cumin	11 / 137	8.0
Capsicum	35 / 492	7.1
Tumeric	8 / 118	7.0
Pepper, black	13 / 291	4.5
Fennel/Fenugreek/Mustard	3 / 112	6.6
All Imported Spices	**187 / 2844**	**6.6**

J. M. Van Doren et al. Food Microbiol. 34:239 (2013)

Prevalence of *Salmonella* in Imported Spices to USA, FY 2007 - FY 2009

Spice	*Salmonella*-positive	
	No. pos./No. sampled	Prevalence (%)
Spices subjected to pathogen reduction treatment	**4 / 138**	**3.0**
Spices not treated	183 / 2707	6.8
Spice blend	43 / 790	5.4
Ground/cracked spice	131 / 1658	7.9
Whole spice	51 / 884	5.8

J. M. Van Doren et al. Food Microbiol. 34:239 (2013)

Examples of USA Recalls of Spices for *Salmonella* Contamination

YEAR	PRODUCT	PATHOGEN
2006	Veggie Booty (Seasoning)	*Salmonella* Wadsworth
		Salmonella Typhimurium
2007	Peppercorns	*Salmonella* spp.
2007	Sesame Seeds	*Salmonella* spp.
2007	Mojito Cocktail Garnish (Parsley Powder)	*Salmonella* spp.
2009	Red, Black and White Pepper	*Salmonella*
2009	Curry	*Salmonella*
2009	Wasabi Powder	*Salmonella*
2009	Chili, crushed	*Salmonella*
2010	Nutmeg	*Salmonella*
2010	Black Pepper (Vietnam)	*Salmonella* Montevideo
2010	Red Pepper (China, Japan)	*Salmonella* Montevideo
2010	Garlic Powder	*Salmonella*

Black Pepper Harvest – India

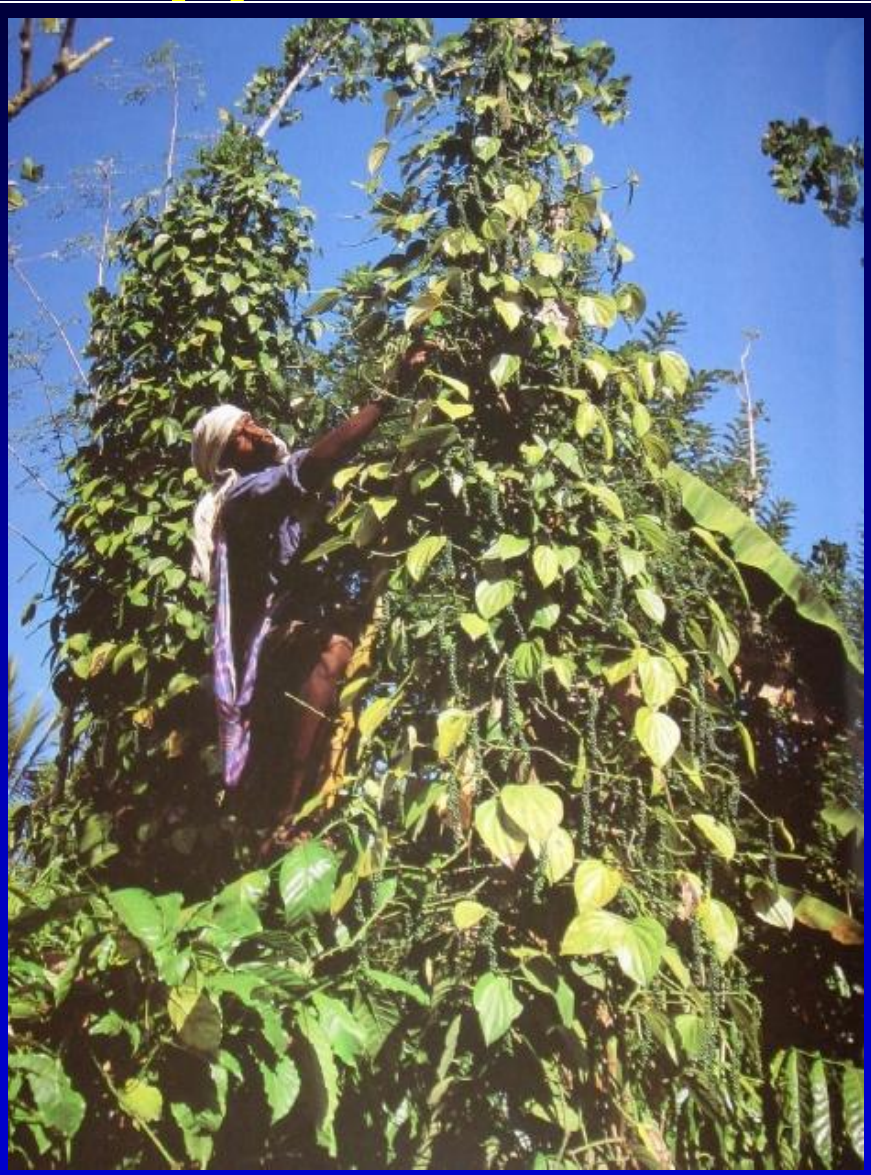


Photo from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Black Pepper Drying – India

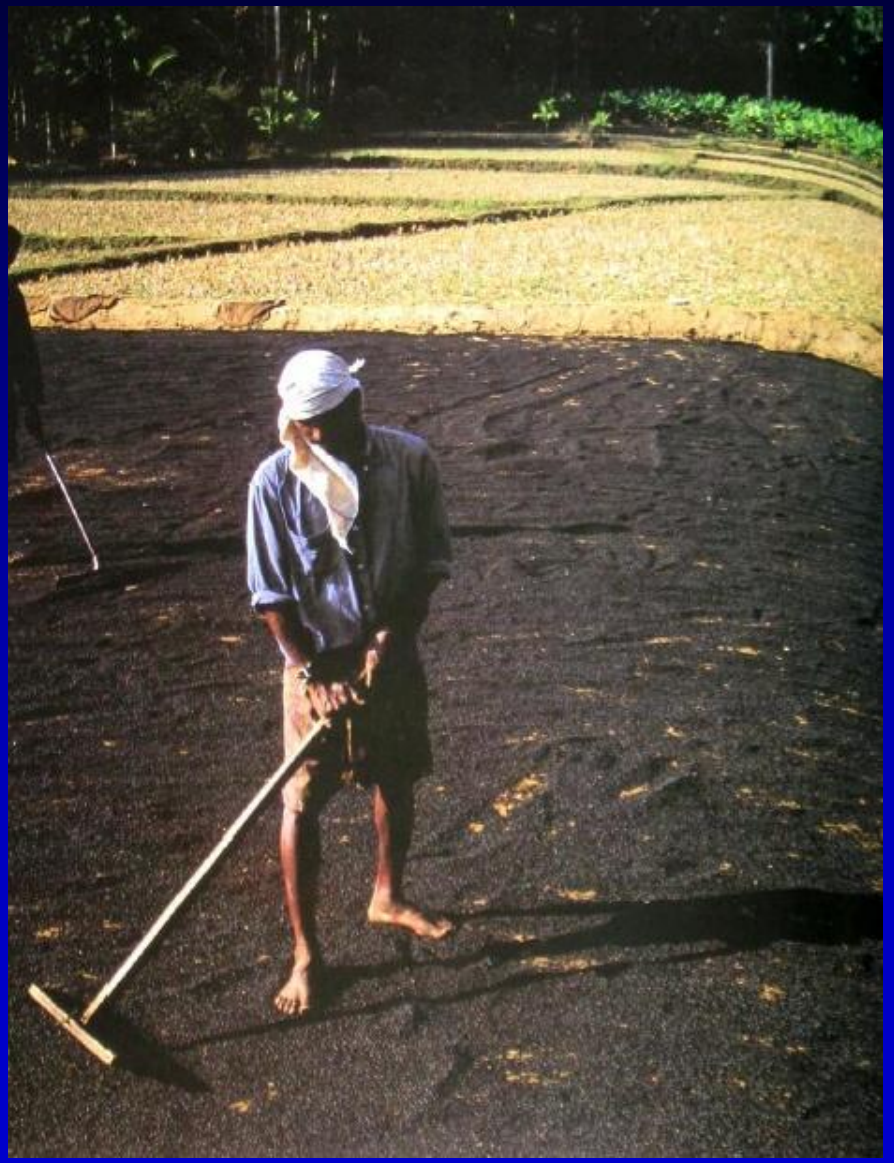


Photo from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Red Pepper Harvest – India

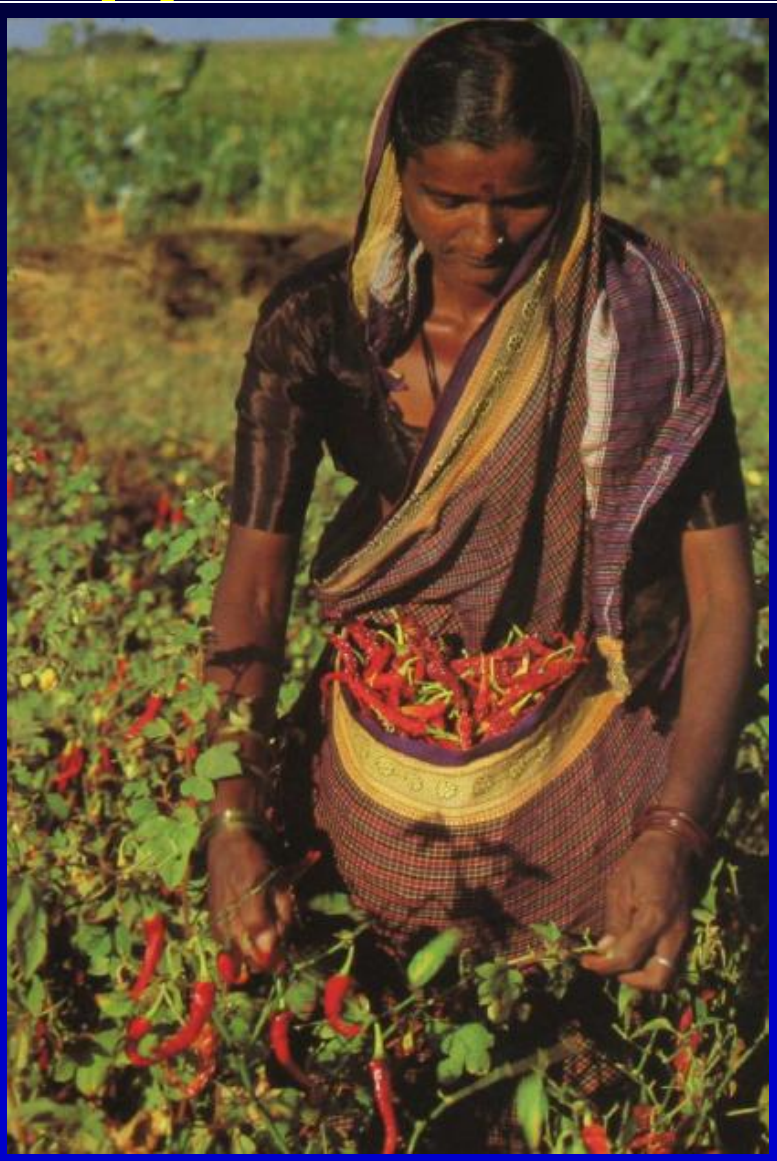
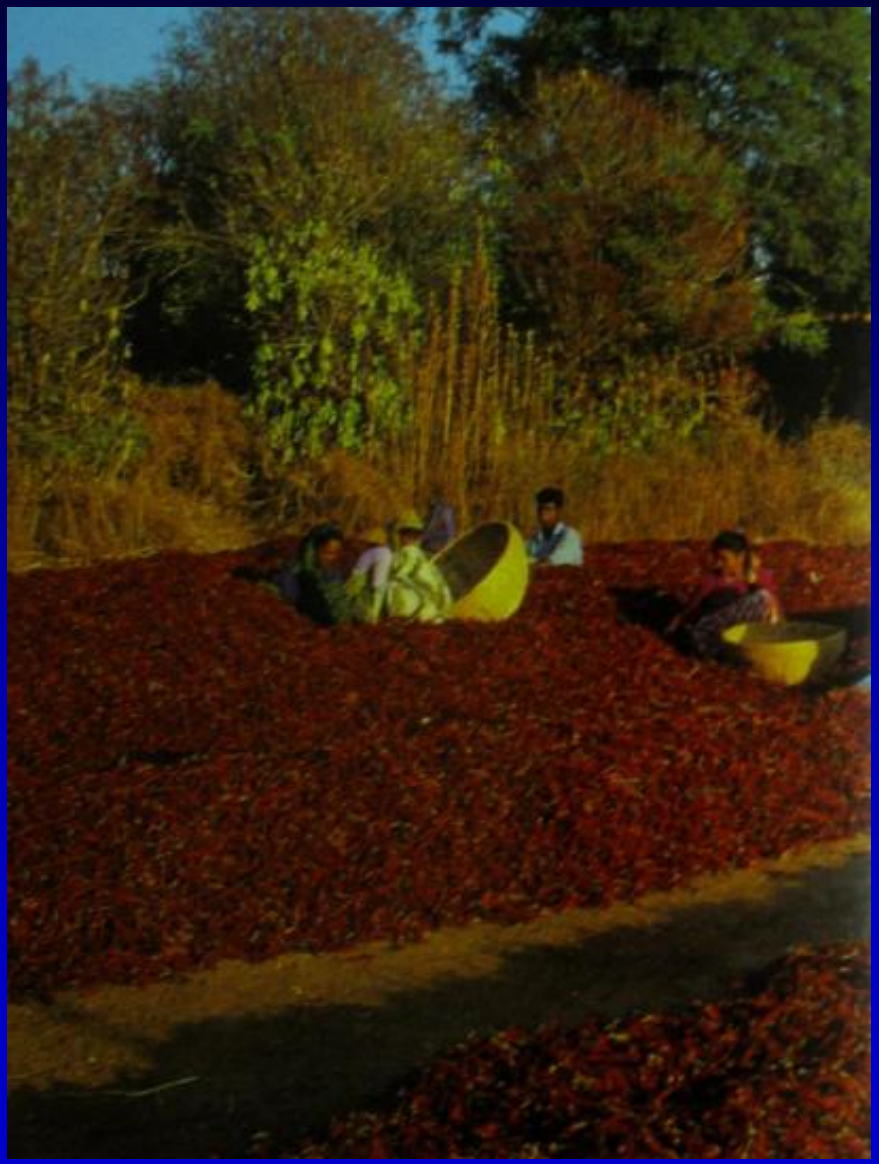


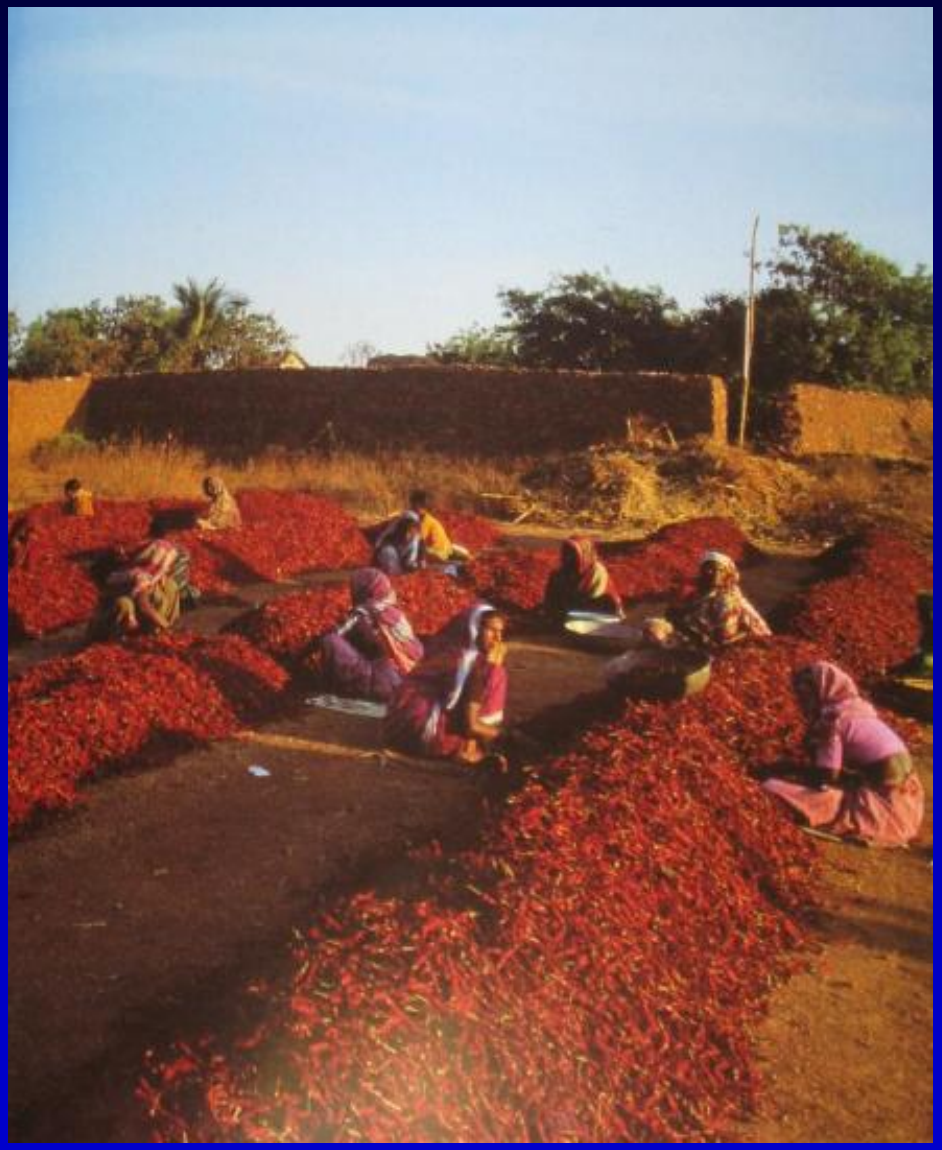
Photo from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Red Pepper Transport – India

Photo from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Red Pepper Drying – India

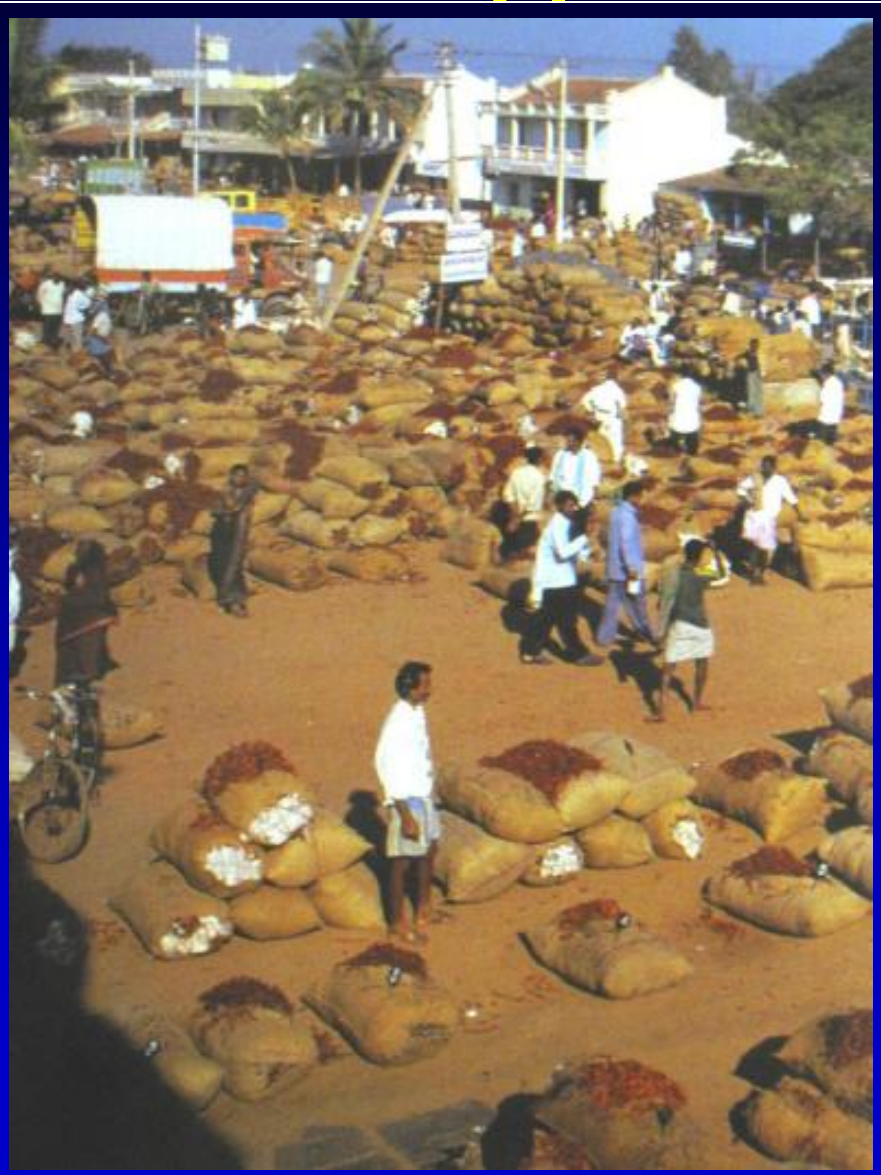


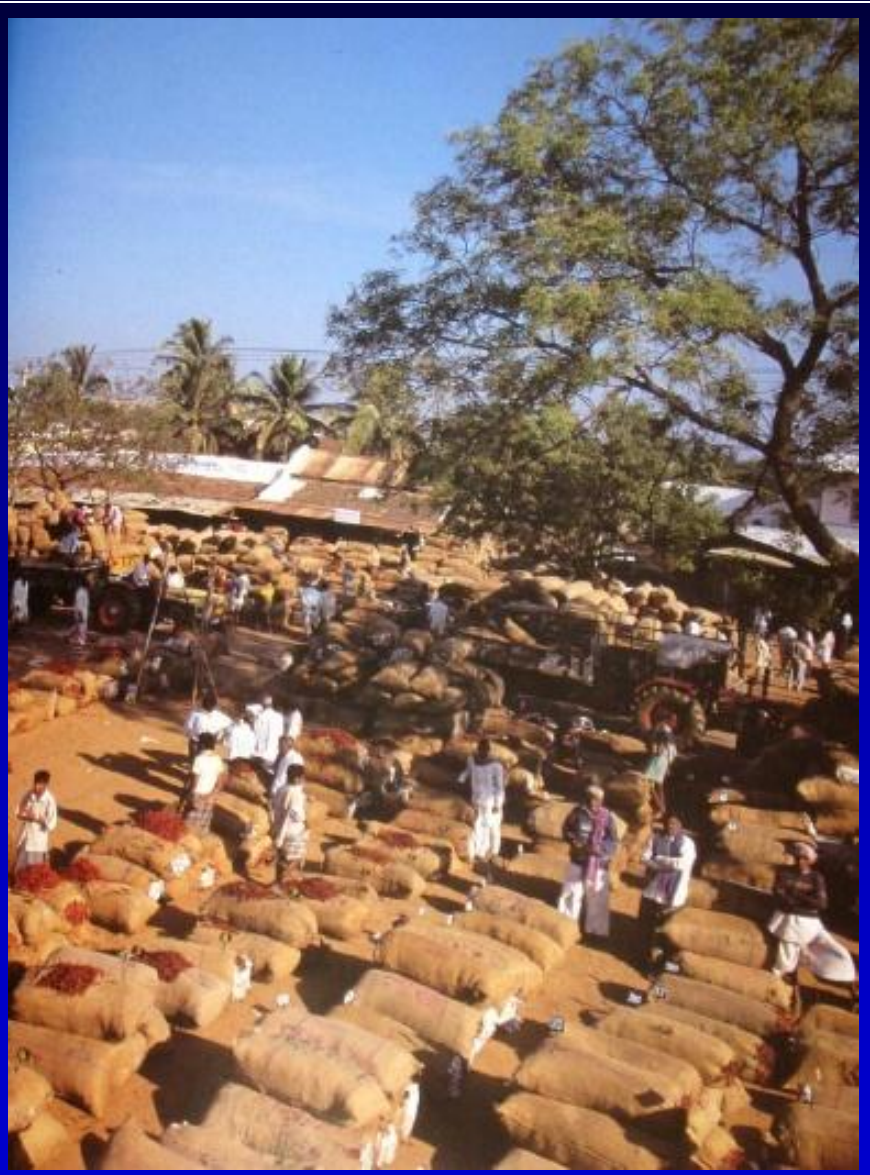


Photos from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Red Pepper Collection and Storage– India

Red Pepper Trade Market – India





Photos from Indian Spices, by A. G. Mathew Ph.D and Salim Pushpanath

Treatments for Spices

- Irradiation
- Ethylene oxide (or propylene oxide)
- Steam
  - All have **adverse effect** on **spice quality** characteristics (flavor, odor, color) or are **not acceptable to consumers** so may not be applied or be applied at doses less than needed to kill foodborne pathogens like *Salmonella*

Challenges to US Processors of Globalization on the Safety of Food Ingredients

- Cost-cutting by foreign sources
- Economically-motivated adulteration by foreign sources
- Practices by foreign sources used in food production/processing not acceptable in USA
- Pathogen contamination

Concerns Regarding Safety and Quality of Food and Food Ingredients from China

- *Salmonella*
- Pesticides
- Heavy metals
  - Lead, arsenic
- Economically-motivated adulteration

Economically-motivated Adulteration

- **Melamine** in **dairy products and pet foods** to fraudulently increase apparent nitrogen content
- Old **leather** in **dairy products** to increase apparent protein content
- **Ground limestone** in **flour** to increase weight
- Feeding **clenbuterol (fat-burning drug)** to **pigs and cattle** to speed up and increase muscle mass
- **Counterfeit certification** of nonorganic crops, including soybeans, millet and buckwheat, as **organic**

China's Melamine Contamination Highlights Human Food Chain Risks

- "The discovery of melamine in eggs as well as in baby formula, milk products, biscuits, chocolates and other food stuffs containing milk derivatives confirms what experts have long suspected; that the chemical is deeply embedded in the (Chinese) human food chain."

T. E. Lyn, Reuters, Nov 3, 2008

China's Melamine Contamination Highlights Human Food Chain Risks

- "And it's not just melamine; heavy metals such as lead and mercury . . . as well as cadmium . . . pesticides and antibiotics are all present in the (Chinese) human food chain."
- China is a major transgressor as carcinogenic chemicals are regularly used as food colouring agents or as preservatives, experts say."

T. E. Lyn, Reuters, Nov 3, 2008

China's Melamine Contamination Highlights Human Food Chain Risks

- "In China, food safety is not a concern and all sorts of things like Sudan red, Malachite green are added in food, so food contamination is widespread."

T. E. Lyn, Reuters, Nov 3, 2008

FDA Import Refusals for Contamination of **Soy Protein Isolate from China** between Nov 2011 - Apr 2012

Company	Date	Reason for Refusal
Sandong Crown Soya Protein	04/23/12	**Melamine**
Wenda Co Ltd	02/09/12	**Melamine**
Nanjing Sun Brain Garments Co Ltd	01/19/12	**Melamine**
Gushin Biological Technology Group Co Ltd	12/12/11	**Melamine** ***Salmonella***
Shandong Gushin Imp & Exp Co Ltd	12/05/11	**Melamine**
Shandong Yuwang Industrial Co Ltd	11/01/11	**Melamine**

Soy Protein Isolate is a Highly Sensitive Food Ingredient from a Food Safety Perspective

- Added to many foods as an ingredient that do not thereafter receive a heat or pathogen-kill treatment, and are ready-to-eat
- Examples of RTE soy protein-containing foods:
  - Nutrition bars
  - Ready-to-drink powders for beverages
  - Infant formula
  - Reduced-fat peanut butter

Unintended Consumer Uses of Foods with Adverse Food Safety Consequences

- Raw, uncooked foods of animal origin
- Fresh-cut produce
  - Bagged spinach
  - Raw sprouts
  - Fresh-cut fruits/melons
- Flour (raw)
  - Cake batter in ice cream
  - Cookie dough
  - Coat candies
- **Microwave heating vs. cooking**

Foodborne Outbreaks Associated with Foods/Ingredients Intended to be Cooked before Consumption but Consumed Uncooked or Undercooked

Product	Year	Company	Causative Agent	No. of Illnesses
Raw cake batter in ice cream (Likely Flour)	2005	Cold Stone/General Mills	*Salmonella*	26
Banquet Frozen Pot Pies (Microwave issue)	2007	ConAgra	*Salmonella*	401
Totino's & Jeno's Frozen Pepperoni Pizza (Microwave issue)	2007	General Mills	*E. coli* O157:H7	21
Marie Callender Frozen Cheesy Chicken & Rice Meal (Microwave issue)	2008	ConAgra	*Salmonella*	37
Toll House Cookie Dough (Likely Flour)	2009	Nestle	*E. coli* O157:H7	75
Frozen Mini Pizza Slices, Frozen Mini Chicken & Cheese Quesadillas (Microwave issue)	2013	Farm Rich Products	*E. coli* O121	35

In-home Microwave Heating is Not a Reliable Treatment to **Kill** Foodborne Pathogens

- Salmonellosis outbreak (>400 cases; 41 states) associated with frozen, **not RTE pot pies (intended to be cooked)** (Oct 2007)
- **Limitations** of **in-home microwave cooking:**
  - **Variability in magnetron power** of microwave units
    - Some microwave units not able to boil water in 10 minutes
  - Actual practice by many users is **to heat food to warm temperature and eat**; not to cook and kill harmful microbes
  - Heating from frozen state or presence of bone can result in **cold spots**
  - Microwaving **low-moisture ingredients** (e.g., dried spices) or foods (e.g., peanut butter) will likely **not** heat sufficiently to **kill pathogens**

In-home Microwave Heating is Not a Reliable Treatment to Kill Foodborne Pathogens

- **Learnings**
  - **Sensitive ingredients** in foods meant to be cooked by in-home microwave heating should be **pathogen-free (RTE)**
  - **Cannot rely on consumer to properly cook** by microwave heating foods that appear to be RTE

Future Trends in U.S. Importation of Foods

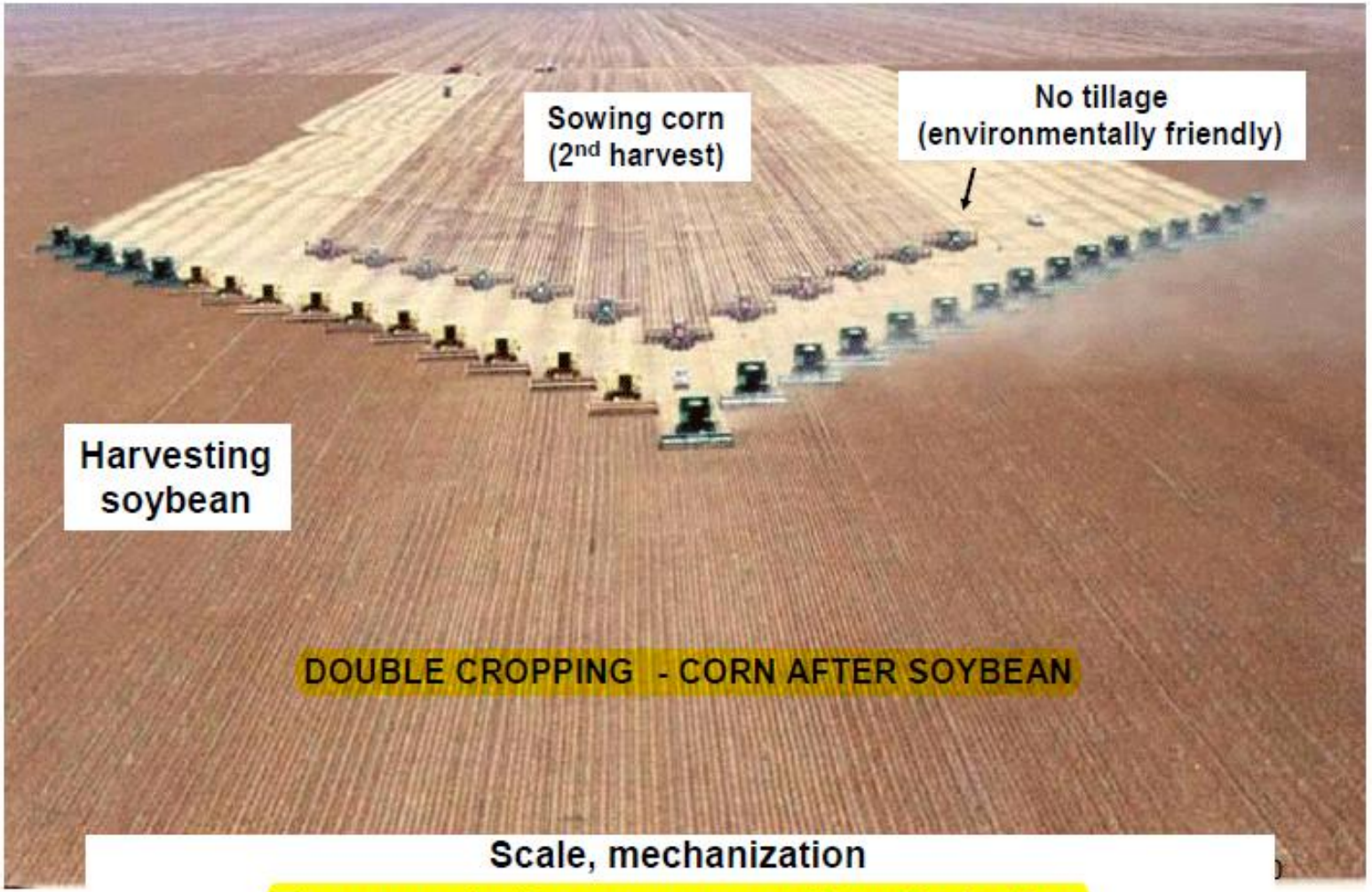
- **California produce** production **shifting to Mexico** and other countries
- **China** becoming major food **exporter to USA**
- **Brazil** dominant **global** agricultural producer and **exporter worldwide**

2009 RANKING: BRAZILIAN PRODUCTION AND EXPORTS

Main Products	Production	Exports	Number of Markets	Exports US$ Billion
Sugar	1st	1st	124	8.378
Coffee	1st	1st	81	3.762
Orange Juice	1st	1st	75	1.619
Soybeans	2nd	2nd	46	11.413
Beef	2nd	1st	142	4.118
Tobacco	2nd	1st	100	2.992
Ethanol	2nd	1st	48	1.338
Broiler	3rd	1st	146	5.307
Corn	4th	3rd	49	1.259
Pork	4th	4th	81	1.225

Sources: USDA and MAPA

TECHONOLOGY and ENTREPRENEURSHIP



Scale, mechanization

Two crops in the same year without irrigation

Pressures on USA Agriculture

- **Water**
  - **Availability**
    - CA and Southwest USA agriculture highly dependent on irrigation
  - **Salinity, heavy metals**
- **Land costs** (especially near urban areas) and **taxes, equipment costs,** and **loan restrictions**
  - Cost prohibitive for younger generation
- **Environmental contamination**
  - Manure (pathogens, odor, water)

Pressures on USA Agriculture

- **Labor**
  - Unappealing but critical jobs
  - Low income (minimum wage)
  - Large percentage of migrant labor
- **Competing economic and land use interests** within states
  - Example – Florida: retirement/healthcare, tourism
- **Low profitability** if not large operation (e.g., > 200 head of dairy cattle) or specialty product (e.g., organic food)
  - **Younger generation of farm families leaving the farm**

Average Age of USA Farmers is Increasing

- The average age of farm operators increased from **50 years old** in **1979** to **57 years old** in **2007**
  - Farmers 55 years of age or older account for 62% of all farms

Feedstuffs, June 13, 2011, p. 6-7

Pressures on USA Agriculture

- **Food imports**
  - Low-cost **labor** (e.g., China pay 50¢ - $2.50/hr)
  - **Water availability** (e.g., Brazil has available water; may be future limitation for China)
  - **Low-cost land** available (e.g., Brazil)
  - Naturally **fertile soil**, grow crops twice per year (e.g., Brazil)
  - **Minimal/reduced food safety and/or environmental contaminant standards** (e.g., pesticide and antibiotic use in China; lead in environment, water and food in China; economically-motivated adulteration in China)

Future Food Safety Concerns for Public Health

- **Aquaculture farming** will become a dominant global food production practice. Excessive use of **antimicrobials** critical to human therapy for disease control and use of **raw animal manure and human feces** as primary nutrient source has global ramifications regarding antimicrobial-resistant microbes and pathogen contamination

Future Food Safety Concerns for Public Health

- **Sensitive food ingredients**, such as spices and nuts, are likely under-recognized vehicles of foodborne outbreaks and will likely become more frequently identified as sources of outbreaks

Future Food Safety Concerns for Public Health

- **Adulterating foods** with fraudulent and even unsafe additives by some exporting countries continues to be an issue

Future Food Safety Concerns for Public Health

- **New food production practices** such as **aquaponics** can be economically sound but can carry fundamental microbiological food safety risks

Future Food Safety Concerns for Public Health

- **Unintended consumer uses of foods** will continue to increase with growing consumer interest in **raw or undercooked, natural (no preservatives) foods** that can be prepared quickly. This is being accelerated by the use of **social media disseminating misinformation**.