Pasture-based and Integrated Systems: Food Safety Perspective

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Livestock on Diversified Farms: **Integrated Crop-Livestock Systems**

- Mixed/integrated crop-livestock systems are farms where animals and crops are raised with the goal of utilizing the products of one for the growth of the other *(Hilimire, 2011)*

Adapted from [www.ars.usda.gov](http://www.ars.usda.gov)
Livestock on Diversified Farms: *Integrated Crop-Livestock Systems*

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**Other terms:**
- Mixed crop-livestock systems
- Integrated farms
- Bio-diversified farms
- Diversified farms

Adapted from www.ars.usda.gov
Livestock on Diversified Farms: *Integrated Crop-Livestock Systems*

**Specialized systems**

*Courtesy of Monique Gunther*

**Integrated systems**

*Adapted from Wikipedia*
Livestock on Diversified Farms: *Integrated Crop-Livestock Systems*

- **Spatially Separated**
- **Rotational**
- **Fully Combined**

Adapted from reuters.com
Livestock on Diversified Farms: 
*Integrated Crop-Livestock Systems*

**Benefits**

- **Fertilize the soil** with on-farm input, livestock manure
- Encourage and allow growers to maintain **semi-permanent pasture fields**, which can **improve soil quality**
- Increase **crop yield**
- Enhance **on-farm bio-diversity** and related **ecosystem services**: pollination, weed/pest management
- Enhance **economic gain** to growers
- Confer **social benefits** to growers and communities
- **Sustainability** *(Hilimire, 2011)*
Foodborne Pathogens

*Animals on Diversified Farms*

- Certain **animals** are **reservoirs** for certain pathogens
- What can **affect animals shedding** in their feces
  - Age (e.g. young animals)
  - Husbandry practices (e.g. stocking density)
  - Diet (e.g. distillers grain)
  - Season (summer)
  - Environmental conditions
- **Good Husbandry Practices** (prevention)

Adapted from CDC,NARMS
Foodborne Pathogens

Animals on Diversified Farms

- All manures can carry pathogens (causing human illness)

- There is an increased risk of pathogen spread via food products (e.g., vegetables, fruits and nuts) when manure is applied to crop fields

- The direct and indirect use of manure in crops increases the potential for exposure to foodborne pathogens and consequently can become a food safety hazard

Casandra Hernández-Reyes, and Adam Schikora FEMS Microbiol Lett 2013;343:1-7
Foodborne Pathogens
Manure & Risk Reduction

Soil

• Enteric Pathogens can persist for long periods in the soil:
  • *Salmonella* can persist in the litter applied to fields for almost 4 months, can survive up to 2 years
  • *Campylobacter* can persist for about 25 days

• Factors affecting the survival in the soil: livestock species, pathogen, manure type, composition (e.g., humidity, dry matter), soil type, environmental conditions (e.g. season, ambient temperature, rainfall, sunlight, etc.)
Foodborne Pathogens

Manure & Risk Reduction

- Application of raw manure (untreated manure, litter, bedding, aged manure)
- Application of treated/composted manure
- Integration of animals: Pasture-based and grazing systems
Manure & Risk Reduction

Good Agricultural Practices (GAPs)
• Selection
• Handling and storage
• Application timing (time-interval)
• Application methods
• Treatment: composting, heat treatment
• Record keeping
Handling & Storage

- Storage area physically isolated from vegetable garden, open water sources
- Avoid re-contamination (wildlife, pests, etc.)
- Barriers to minimize the risk of leaching, runoff or spreading by wind (roof, surface water diversions to prevent runoff from and into storage area)
- Treatment (e.g., composting, heat treatment)
Manure Application

• The prevention of microbial contamination of crops has been based on time-interval criteria between the application of raw manure and crop harvesting.
• Planning the timing for manure application & harvesting.
• Apply to crops eaten cooked (e.g., potatoes).

National Organic Program (NOP)

Raw manure application
Crop Harvest
90 days 120 days

Foodborne Pathogens
Manure & Risk Reduction
Manure Application

• Manure application and buffer zones
• Application methods and incorporation into the soil as soon as possible
• Minimize the contact of produce with manure (e.g., plastic mulch)
• Manure should not be used to side-dress or top-dress crops
• Cover residues or cover crops to minimize manure nutrient leaching or runoff from fields (filter strips)
• Detail records of treatment methods, application (rates, methods, dates, etc.)
Foodborne Pathogens

**Compost criteria for animal manure**

**Principles:**

- The proper materials
  - Manure sources (different livestock species, bedding material, green waste, etc.)
  - Carbon sources (types)
- Surface area/ particle size
- Volume (challenging for small farms and backyard producers)
- Moisture (moisture level of 40-60)
- Aeration (microbes need oxygen to efficiently decompose complex organic material)
- Temperature (increases as the biological activity of the pile increases)
- Carbon to Nitrogen ratio (ideal 30:1)

- Survival of pathogens
- Risk for re-contamination
Heat (temperature) is the primary factor responsible for inactivation of foodborne pathogens during aerobic composting of animal manures.

- Developing and holding temperatures above 55ºC (131 ºF) for 3 days for static piles or in-vessel systems and 15 days for turned windrows, followed by curing stage (45 days, 2 to 4 months)
Foodborne Pathogens

*Properties of Composting Process to Control Foodborne Pathogens*

- One of the major characteristics of composting systems that affects pathogen inactivation is **temperature & moisture** (stratification)

- Amounts of heat generated depends on **feedstocks incorporated** (e.g., straw, woody materials, rice hulls, shredded paper). C:N Ratio (bedding 25% manure:67% bedding; and feedstocks)
Integrated Crop-Livestock Systems
Manure & Risk Reduction

- Rotational Grazing or Pasture
- Integration of sustainable practices such as the use of grazing animals in fields destined for produce may introduce additional food safety risks
Integrated Crop-Livestock Systems
Manure & Risk Reduction

• **Grazing animals, Working Animals and Animal Intrusion**
• Evidence of potential contamination of produce (during growing)?
• Yes (observation of animals, animal excreta or crop destruction)
  • Can be harvested or not based on measures taken during the growing and assessment of the risks/contamination at the harvesting (FSMA § 112.83)
Persistence of *Escherichia coli* in the soil of an organic mixed crop-livestock farm that integrates sheep grazing within vegetable fields

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**Abstract**
Mixed crop-livestock farms (MCLF) integrate livestock and crops using their animals...
Integrated Crop-Livestock Systems
Rotational Grazing - Sheep
Integrated Crop-Livestock Systems
Rotational Grazing - Sheep

- Grazing animals, Working Animals and Animal Intrusion
- Farmers follow the NOP rule (90 & 120 Days)

National Organic Program (NOP)

- Raw manure application
- Crop Harvest
  - 90 days
  - 120 days

Raw manure application
Crop Harvest
90 days
120 days
Manure & Risk Reduction
Record Keeping

- Developing a recordkeeping system to properly document the compost/manure treatment and applications and support a farm food safety plan
- Type of soil amendment being applied
- Composting method: microbial testing (if applicable), turning times and temperature, feedstocks used,
- Date of application
- Rate (quantity applied per acre)
- Method of application
- What crops will be planted
Research
Current Survey

Online link: https://ucdavis.co1.qualtrics.com/jfe/form/SV_8jMboTtv9LyabAx

Thank you!
Thank you for your attention!

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Foodborne Pathogens

*Properties of Composting Process to Control Foodborne Pathogens*

http://cwmi.css.cornell.edu/smallscale.htm

**Small Scale or Backyard Composting Resources**

- Small Scale or Backyard Composting web site - http://cwmi.css.cornell.edu/smallscale.htm
- NYS Small Scale Compost Demonstration Sites - http://compost.css.cornell.edu/maps.html#Holds_Demos=Yes
- Compost: Truth or Consequences video - http://hdl.handle.net/1813/11313
**Composting**

- *Enclosed or within-vessel composting:*
  - Active compost must maintain a minimum of 131 F for 3 days

- *Windrow composting*
  - Active compost must maintain aerobic conditions for a minimum of 131F or higher for 15 days or longer, with a minimal of 5 turnings during this period

- *Aerated static pile composting*
  - Active compost must be covered with at least 12 inches of insulating materials and maintain a minimum of 137F for 3 days

- **Enteric pathogen criteria (LGMA) FSMA**
  - Fecal coliforms <1000 MPN/gram
  - Salmonella negative / <1/30gram
  - E. coli O157:H7 negative / <1/30gram
Wildlife Intrusions

- Wildlife animals can carry pathogens in their feces:
  - Rodents (gopher, ground squirrels, mice, rats)
  - Birds (wild turkeys)
  - Deer (ex: strawberry outbreak in Oregon)
  - Feral pigs (Salinas spinach outbreak 2006)
- Contamination can occur directly or indirectly (water & soil)
Manure & Risk Reduction

• Contaminated crops by wildlife intrusions

(Adapted from Co-Managing Farm Stewardship with Food Safety GAPS Conservation Practices, Wild Farm Alliance, 2016)
Livestock on Diversified Farms: *Integrated Crop-Livestock Systems*

Pathways of crop-livestock integration

Adapted Steinfeld, 1998
Diversified & Integrated Crop-Livestock Farms

Evaluation of the prevalence and persistence of Shiga toxin-producing *Escherichia coli* (STEC) on organic mixed crop-livestock farms that integrate sheep grazing within vegetable fields

- **Preliminary Data: Year 2 (On-Farm)**
- Crops: Tomatoes
- Field A & B: grazed by sheep; Field C: non-grazed
- **STEC:** 87.5% fecal samples, 13.2% soil

**Figure 1:** The average number of generic *E. coli* in soil samples (MPN/gram) per sampling day for fields A, B and C (field C = control non-grazed field).

**Fig 2:** Percentage of non-O157 STEC positive soil samples per sampling day for fields A & B
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- Preliminary Data: Year 3 (Field Trials-Sheep Barn)
Diversified & Integrated Crop-Livestock Farms

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