Bedding Selection and Management:

An important determinant in producing quality milk

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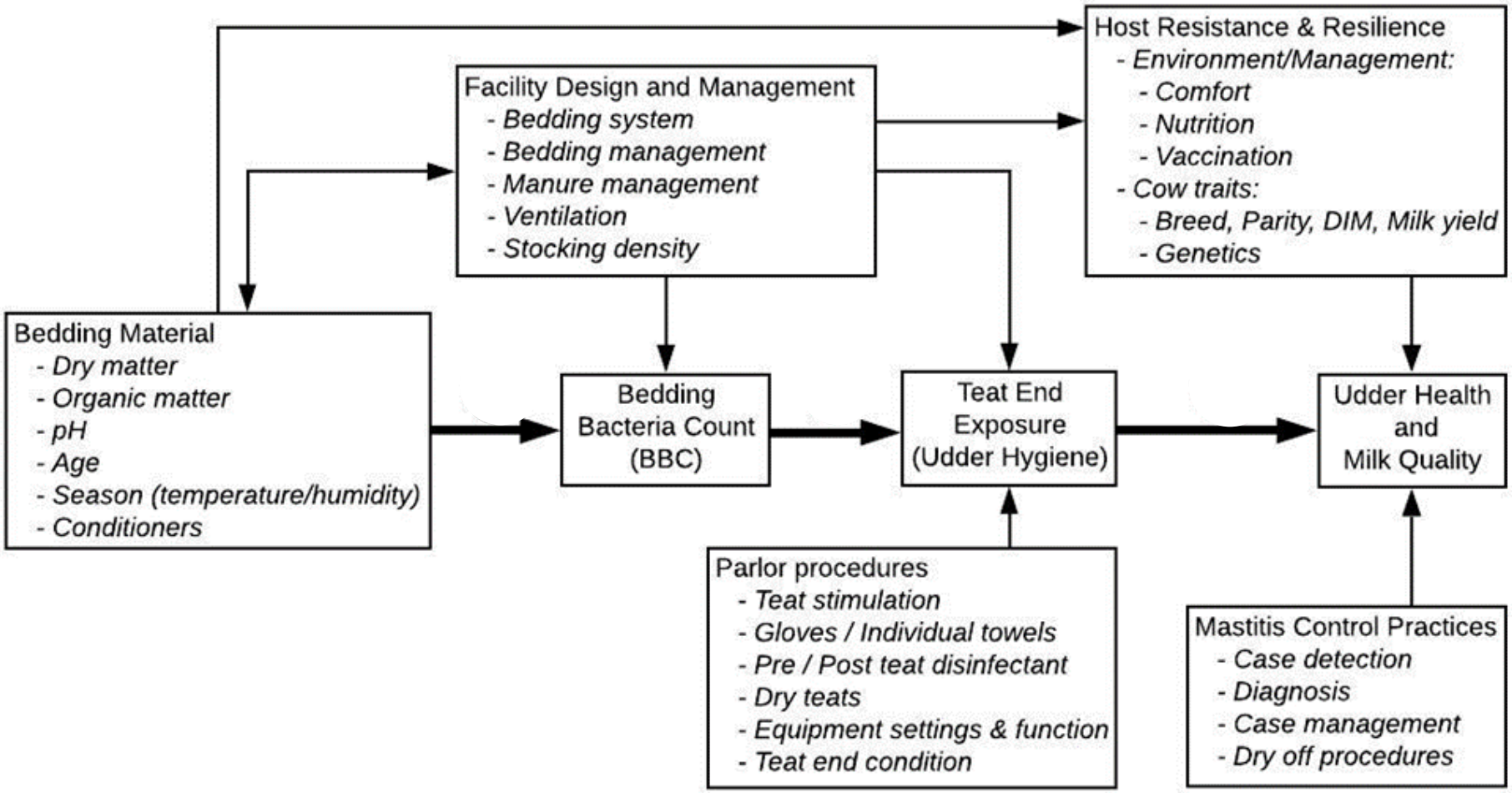
Factors Affecting Udder Health and Milk Quality (imagined)



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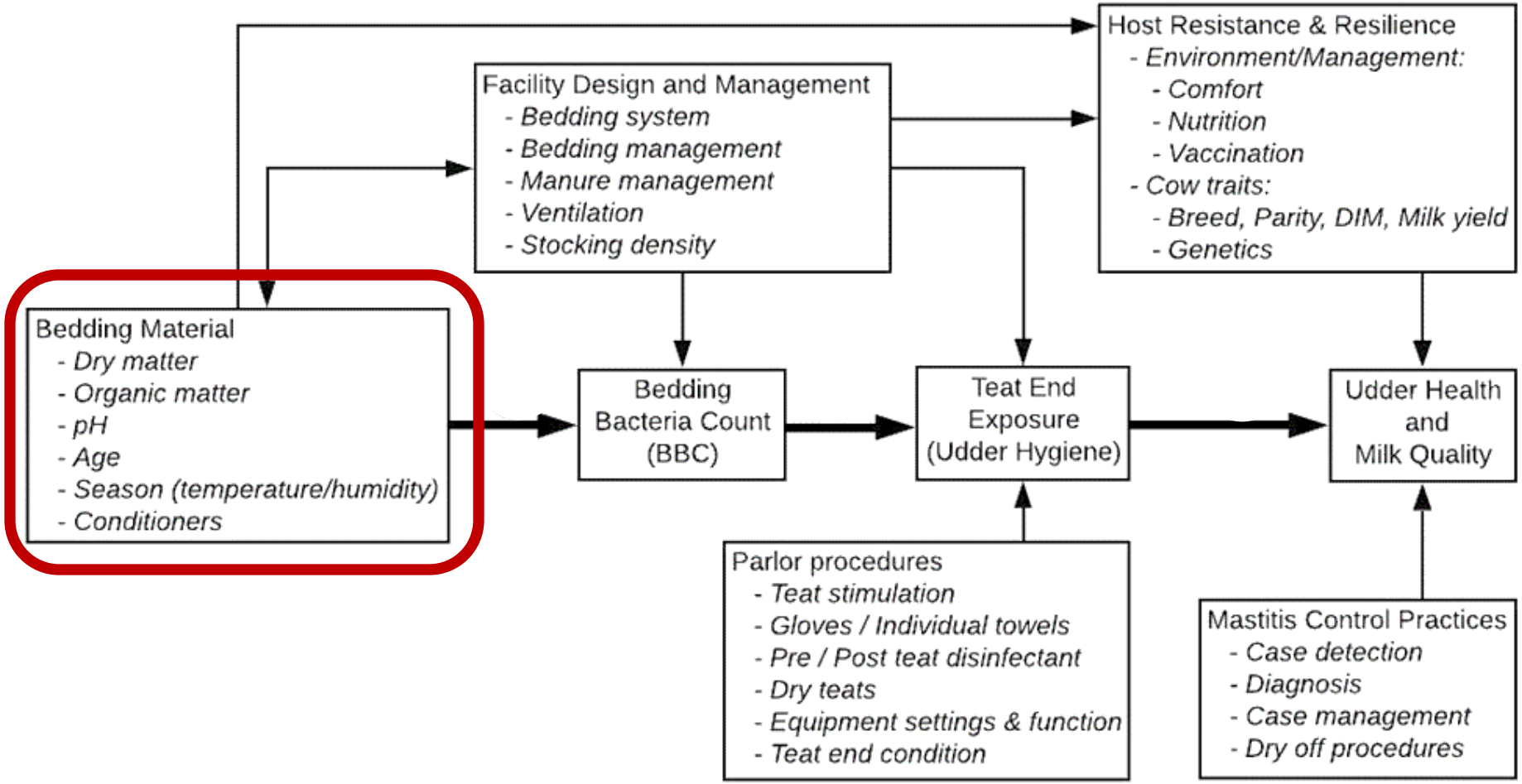
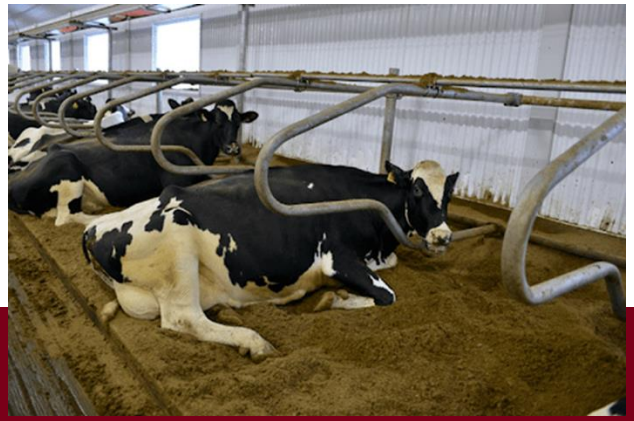


Outline

- Relationship btw bedding bacteria counts & udder health
- Bedding Management:
  - Choose low risk (clean) bedding materials
  - Start with clean ready-to-use (RTU) bedding
  - Bedding management in stalls
  - Examples:
    - Recycled manure solids (RMS)
    - Sand



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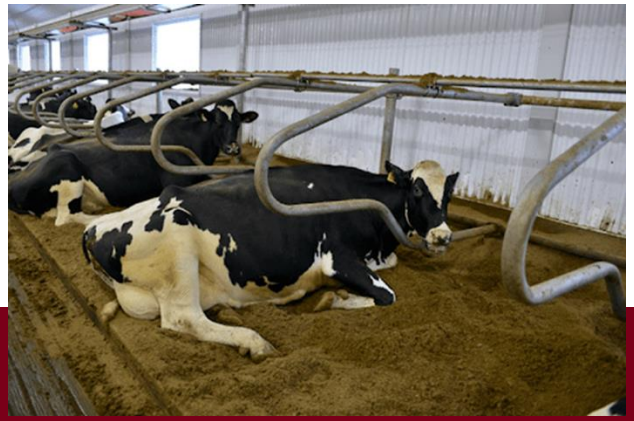
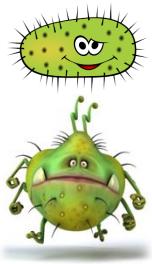


Increased bedding bacteria counts (BBC) are associated with increased mastitis risk



Bedding Bacteria Counts (BBC)

Bacteria counts on teat skin

Increased intramammary infection (IMI) risk in cows
- Clinical mastitis
- Subclinical mastitis (SCC)

Pathogens of concern: Coliforms
Klebsiella spp.
Streptococci and Strep-like spp. (SSLO)
Staphylococcus spp.

Bramley and Neave, 1975; Carroll and Jasper, 1978; Bramley, 1985; Smith et al., 1985
Hogan et al., 1989; Rowbotham and Ruegg, 2016a; Patel et al., 2019; Rowe et al., 2019

We can monitor bedding hygiene

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Laboratory for Udder Health

Mastitis Bedding Culture Report

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(320) 693-9259-(AF.LM)
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Owner:
Veterinarian:
External Ref:
Site:
Premises:
County:

Species: Bovine
Pathologist: Udder Health Accessions

Condition of Samples:			Bedding Culture: Bedding					
Sample Description	Before, After Incubation		Bacillus	Coliforms	Environ Strep	Staph species	Non-coliform Gram Negative	
	Collected		Colonies/ml	Colonies/ml	Colonies/ml	Colonies/ml	Colonies/ml	Total
BEDDING NEW			1,625,000	0 0 % Klebsiella sp.	1,775,000	25,000	35,000	3,460,000

Guidelines for BBC:

https://www.vdl.umn.edu/services-fees/udder-health-mastitis/factsheets-resources

Outline

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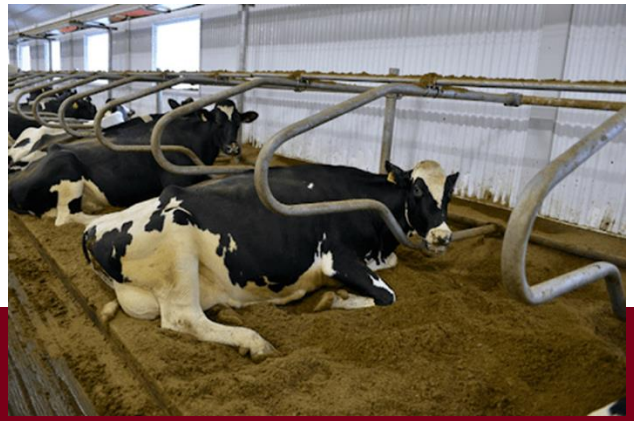


Manure solids (MS)

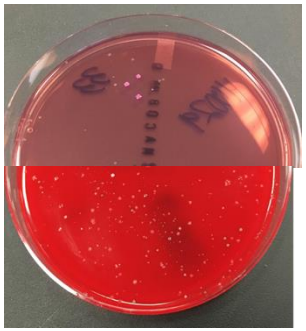
New sand (NS)

Reclaimed sand (RS)

Shavings

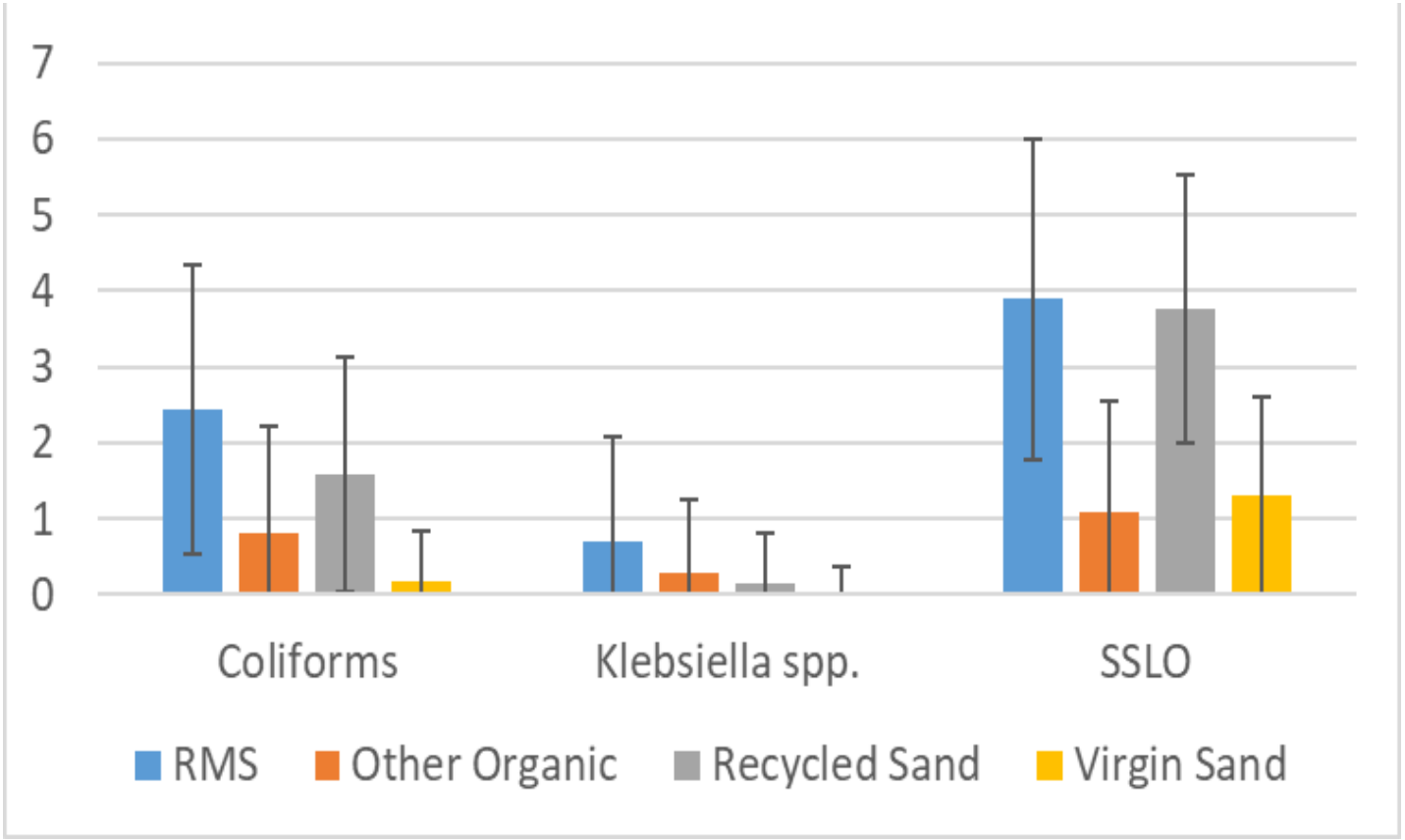
Straw

- When thinking about BBC and udder health..
  - Is there a lowest risk bedding?
  - Is there a highest risk bedding?



Bedding Bacteria Counts (BBC) in Ready-to-Use (RTU) Bedding Materials

(Patel et al., 2019; 168 herds in 17 states)



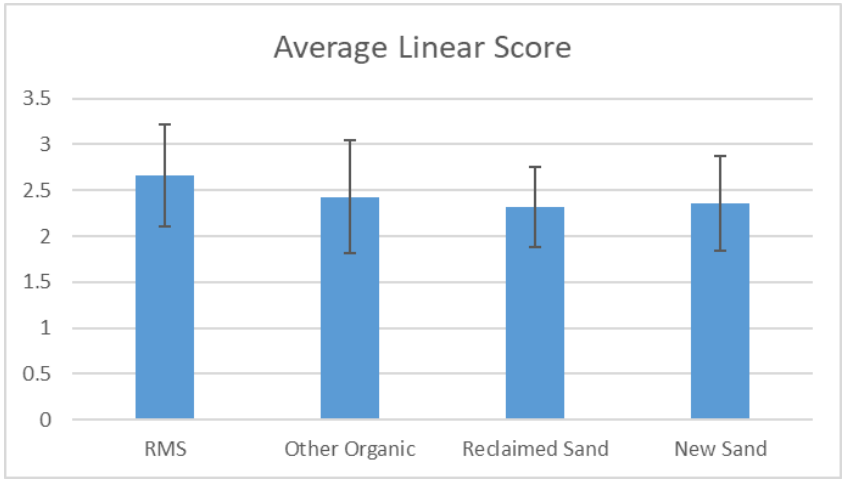
Bars indicate Standard Deviation

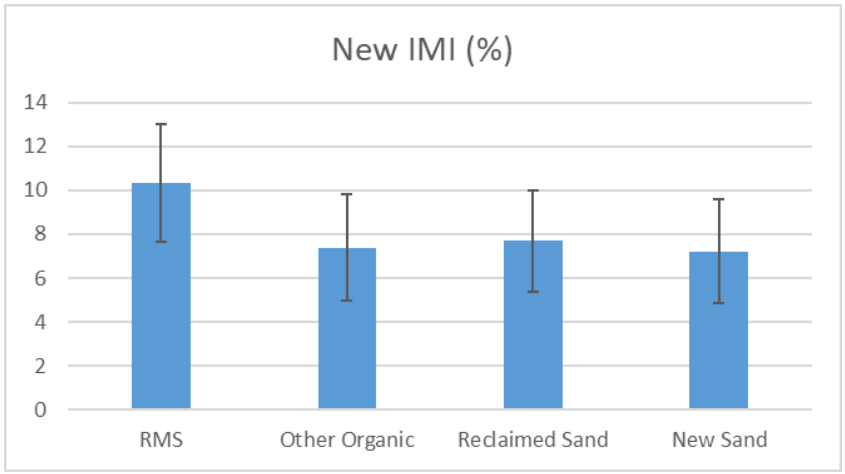




Test Day SCC by Bedding Material

(Patel et al., 2019; 168 herds in 17 states)





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Studies reporting on the relationship between bedding material and udder health

Study	Design	Finding
Bramley, 1985	RCT. 1 dairy	- Lower coliform incidence in sand vs sawdust
Rowbotham & Ruegg, 2016a	RCT. 1 dairy. 15 mos. Lact=1	- Tendency for longer time to a first clinical mastitis case if NS (vs RS or MS) - No difference in LS or milk yield
Esser et al., 2019	RCT. 1 dairy. 3 yr. Lact=1	- Fewer clinical cases if bed on NS or RS (vs MS) - No difference in LS or milk yield
Robotham & Ruegg, 2015	Observational. 325 WI herds. 2 yr	- Herds using inorganic (vs ON or MS) bedding had ↓ BT SCC, ↑ milk yield, ↓ % cows with discarded milk or blind quarter
Wenz et al., 2007	Observational. 1,013 U.S. farms	- Increased BT SCC in herds using composted MS bedding (vs other)
Rowe et al., 2019	Observational. 80 U.S. farms	- No relationship between bedding material and risk for quarter-level IMI in late lactation cows
Patel et al., 2019	Observational. 168 U.S. farms	- Increased herd-level DHIA measures (e.g. Avg. LS, New IMI) in herds using MS - No difference between NS, RS, ON





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Essel [illegible] 2019	RCT. [illegible] 3 yr. Lact=1	- [illegible] (vs MS) - No difference in LS or milk yield
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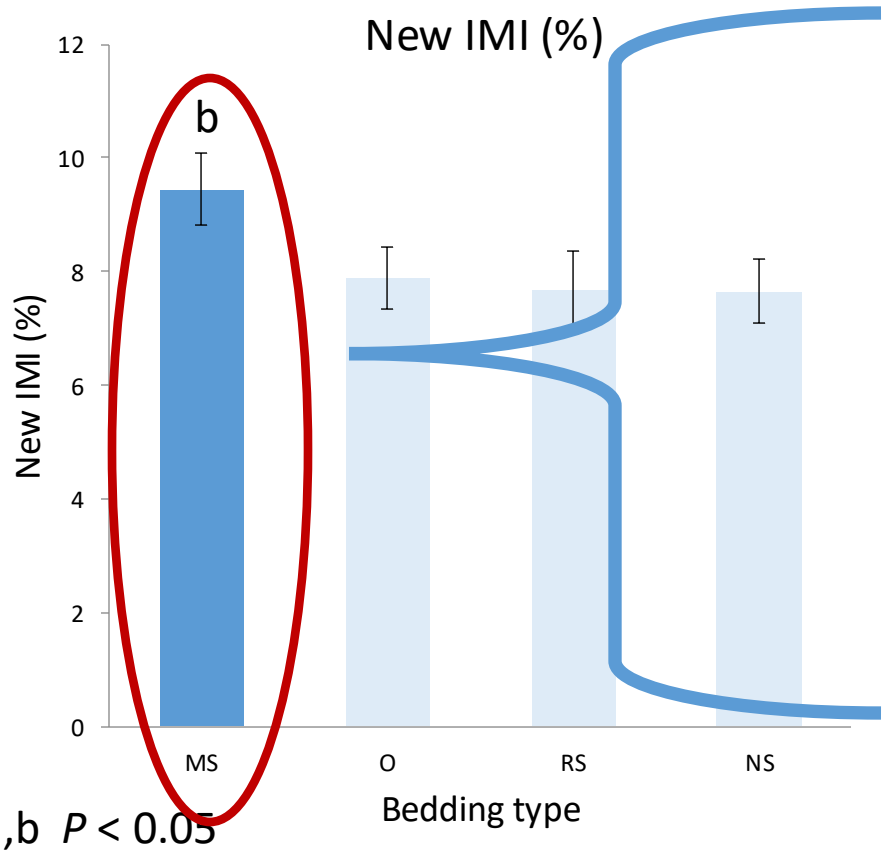
Sand = Generally best udder health

Manure solids = Generally worst

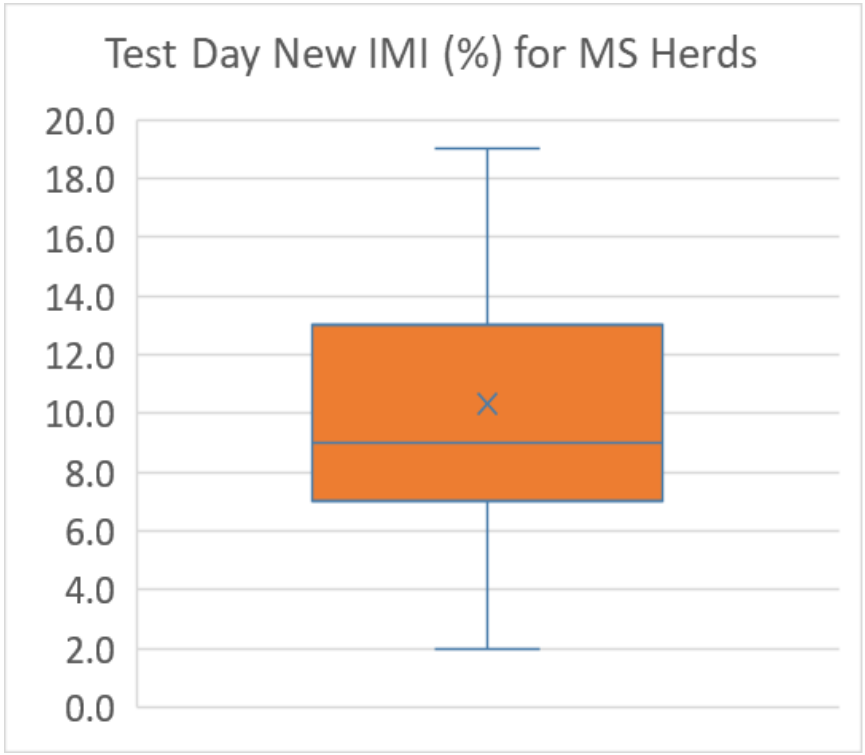
…but not always

Though worse on average, some herds using RMS bedding had low BBC and good udder health

(Patel et al., 2019; 168 herds in 17 states)

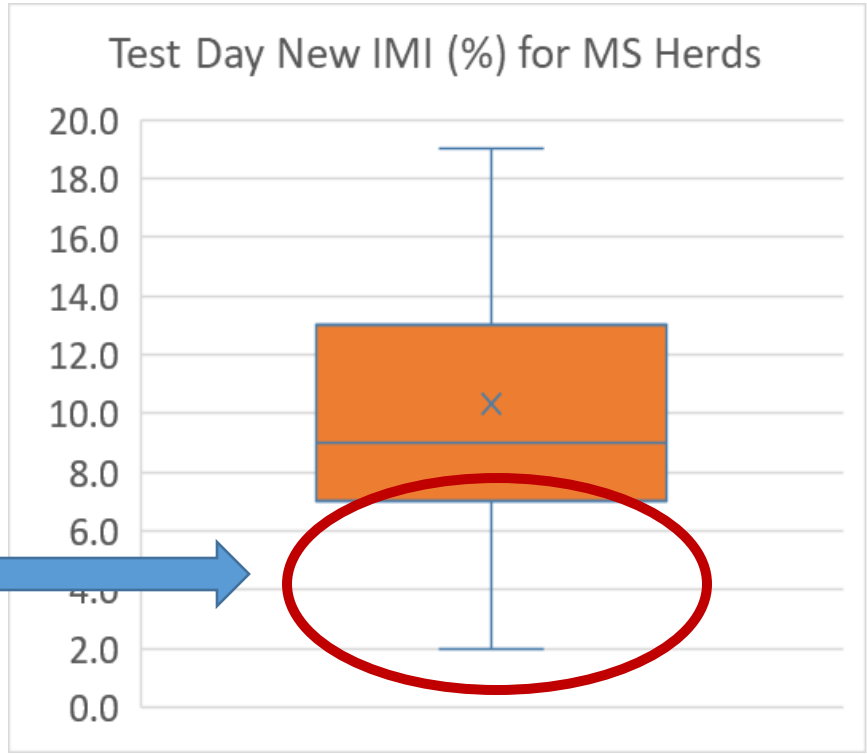


a,b $P < 0.05$

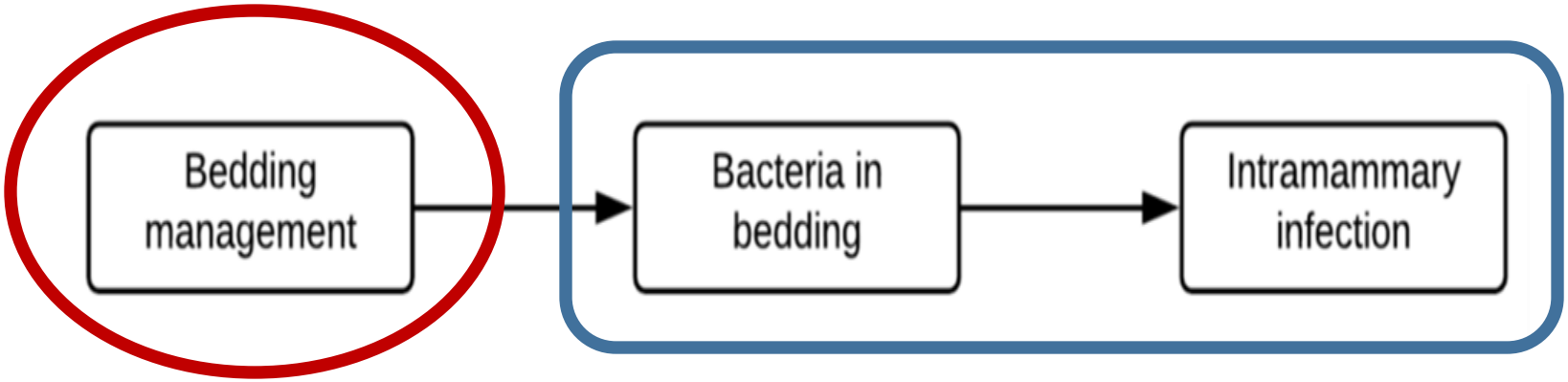


Not all herds using Manure Solids Bedding had Poor Udder Health

Patel et al., 2019; Rowe et al., 2019



Relationship between Bedding Management, BBC and Udder Health?



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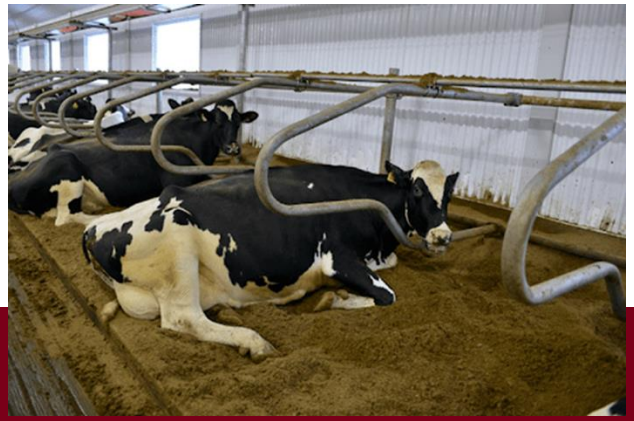

Recycled Manure Solids (RMS) Bedding

- Monitoring and goals for RMS bedding characteristics
- Producing clean RTU RMS bedding
- Management in stalls

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Monitoring/Goals for RMS Bedding

- Clean / Bedding Bacteria Counts (BBC)
- Dry matter (%)

We can monitor bedding hygiene using culture

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Sampling instructions & guidelines/goals for BBC:

https://www.vdl.umn.edu/services-fees/udder-health-mastitis/factsheets-resources

Suggested Benchmarks for BBC in RMS Bedding

(cfu/cc wet bedding) (Patel et al., 2019)

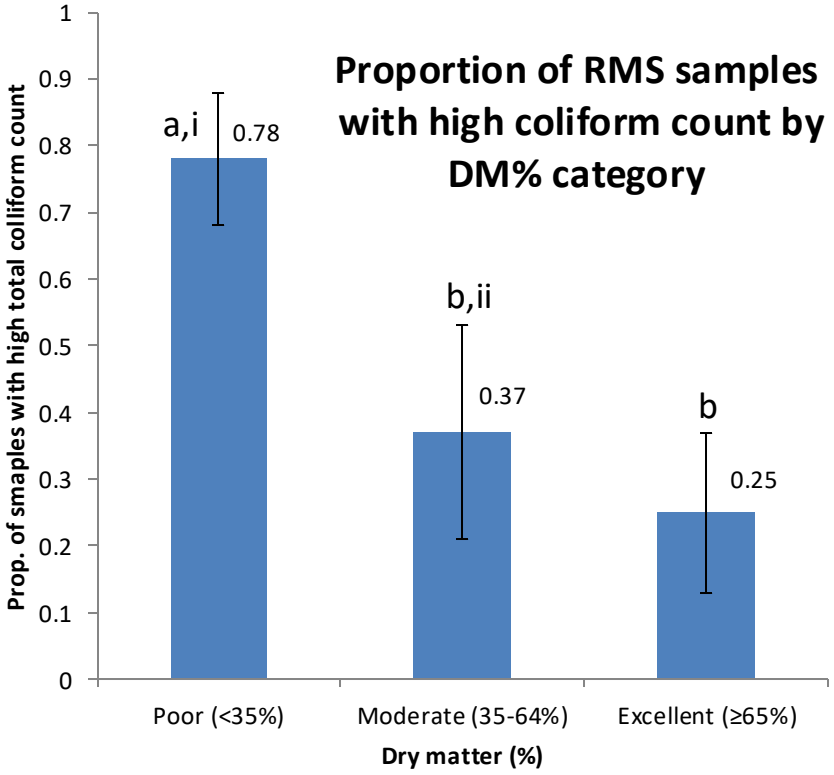
Ready-to-use RMS Bedding

Bacteria Group	Low	Moderate	High
Staph spp.	0	.	>0
Klebsiella spp.	0	.	>0
Coliforms	≤ 500	.	>500
SSLO (*Strep* spp.)	≤ 1,000	1,000 – 750,000	>750,000

Used RMS Bedding (from stalls)

Bacteria Group	Low	Moderate	High
Staph spp.	0	.	>0
Klebsiella spp.	0	.	>0
Coliforms	≤ 10,000	10,001 – 200,000	>200,000
SSLO (*Strep*. Spp.)	≤ 500,000	500,001 – 2,000,000	>2,000,000

Goal for DM% for RTU RMS bedding: ≥ 35%



RMS Dry Matter Categories

Low (Wet):	<35% DM
Moderate:	35-64% DM
High:	≥65% DM

i, ii – significant at $p \leq 0.1$
a, b – significant at $p \leq 0.05$

Note: 1. DM ≥ 65% not a reasonable goal in humid/wet regions
2. If excessively dry (>45-50%), increase dust / material blows out of stalls
3. DM/BBC relationship is confounded by 2° proc. method: *See later slides*

Hogan and Smith, 2012; Bradley et al., 2018; Godden et al., 2019

Recycled Manure Solids (RMS) Bedding

- Monitoring and goals for RMS bedding characteristics
- Producing clean RTU RMS bedding
- Management in stalls

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Management to produce clean RTU RMS

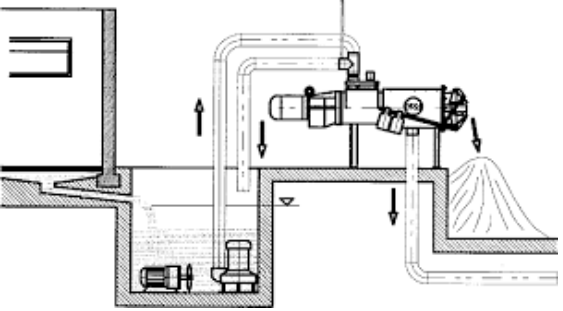
- Primary separation of liquid and solids
- Secondary processing of slurry and/or separated solids

RMS Processing methods on Midwest Dairies

Slurry

Screw press

Green solids



Semanticscholar.org

Primary separation of liquid and solids

Tridentprocesses.com

- Primary separation with press:
  - Can achieve only minor manipulation of DM%
  - Generally still too wet (< 35% DM)
  - No impact on pathogen levels

Screw press
dlsbiogas.com

Roller press
Tridentprocesses.com

Centrifuge
Tradewheel.com

Management to produce clean RTU RMS

- Primary separation of liquid and solids
- Secondary processing:
  - Anaerobic digesters (Prior to liquid/solid separation)
  - Composting
  - Mechanical hot air drying
  - Infrared drying

Tridentprocesses.com

Can processing of RMS ↓BBC?

Digester

Digested ~37°C / 98.6°F
≥ 15 d retention
(then pressed)

Composting
(105-150 °F)

Static Pile (5-10 d)

Windrows (2 wk)

Rotating Drum
Mixes solids with hot air
> 150 °F x 1d

Mechanical Drying

700 °F at entry,
130 ° F at exit,
12-15 min to process

Infrared Drying

30-50' Infrared auger
Exposed to 1000 °F
Exits at ~ 160 °F
~ 14 min. to process
(bluteqinfrared.com)

RMS Processing methods on Midwest Dairies

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Screw press

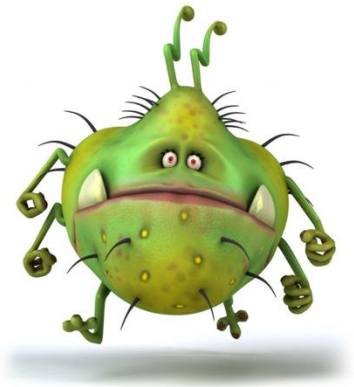
Anaerobic digester

Digested solids

Green solids

How well does Digestion ↓BBC?

Anaerobic Digester



- Increased adoption – methane/carbon credits
- Many bench top studies, but limited large scale studies on commercial dairies
- Burch et al., 2018
  - 7 full-scale digesters on WI dairies x 9 mos
  - Variable pathogen removal
    - Less than anticipated from bench studies
    - High decay coefficient for *E. coli*
    - Low decay coefficient for *Streptococcus* spp.
  - Potential causes of suboptimal performance:
    - Overloading
    - Poor mixing (dead zones)
    - Poor temperature control

Secondary RMS Processing Options on Midwest Farms

Slurry

Screw press

Anaerobic digester

Drum composter

Hot air dryer or IR-dryer

Composted solids

Dried solids

Digested solids

Green solids

Investigating RMS Processing on Midwest Dairy Farms

- **Funding**: UMASH and McLanahan

UMASH Upper Midwest Agricultural Safety and Health Center

McLanahan

- **Objectives**. Describe associations between RMS processing methods and:
  - BBC
  - Udder health
  - Milk production

Results

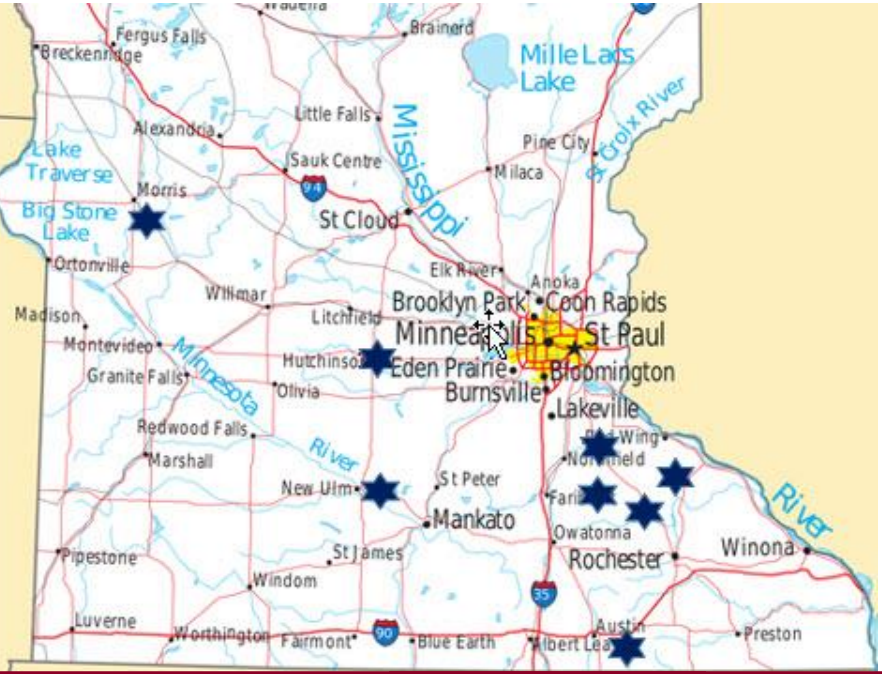
29 Free stall facilities: MN 8, WI 21

Green = 7

Digested = 6

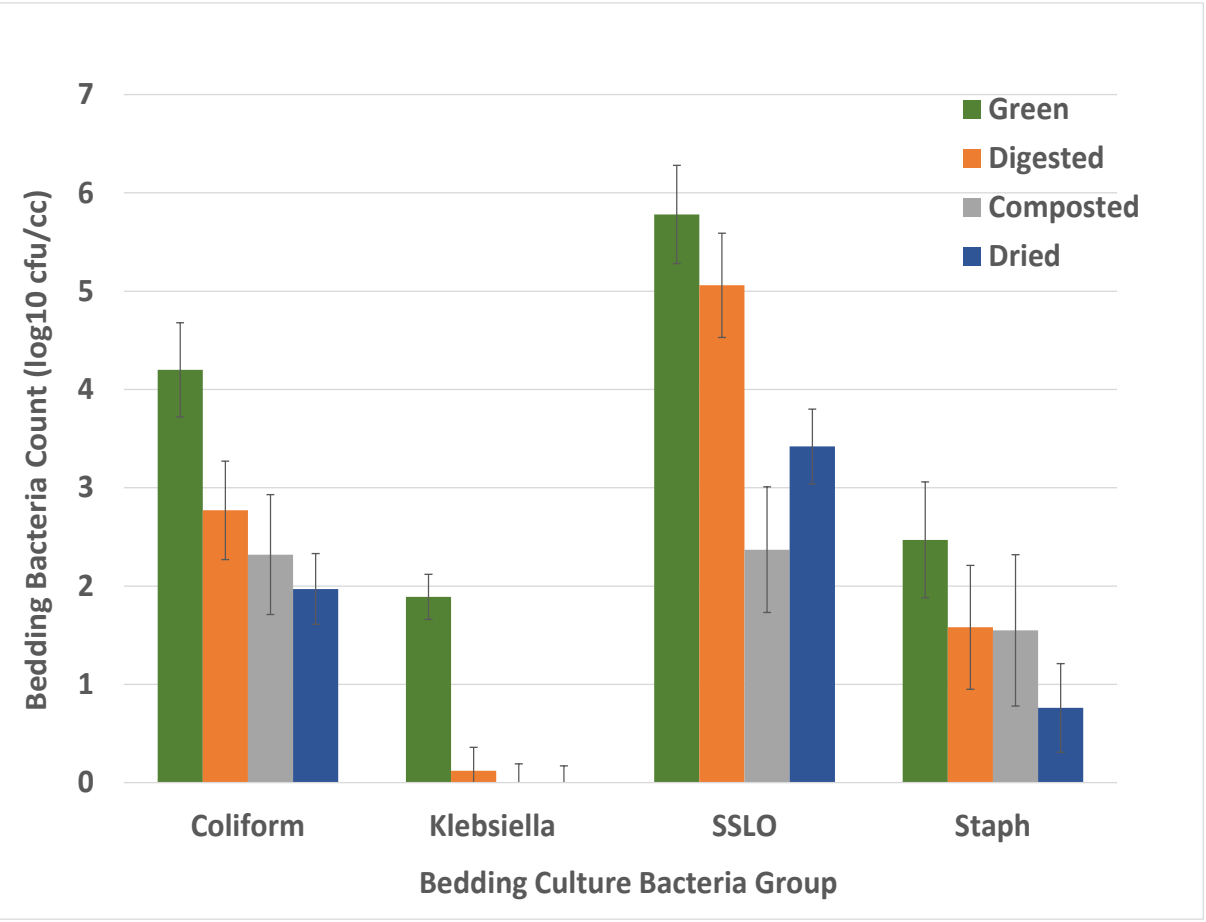
Drum Composted = 4

Dried = 12






Bacteria Counts in RTU Solids by Processing Method



Coliform BBC lower in Dried and tended lower in Composted (vs Green)

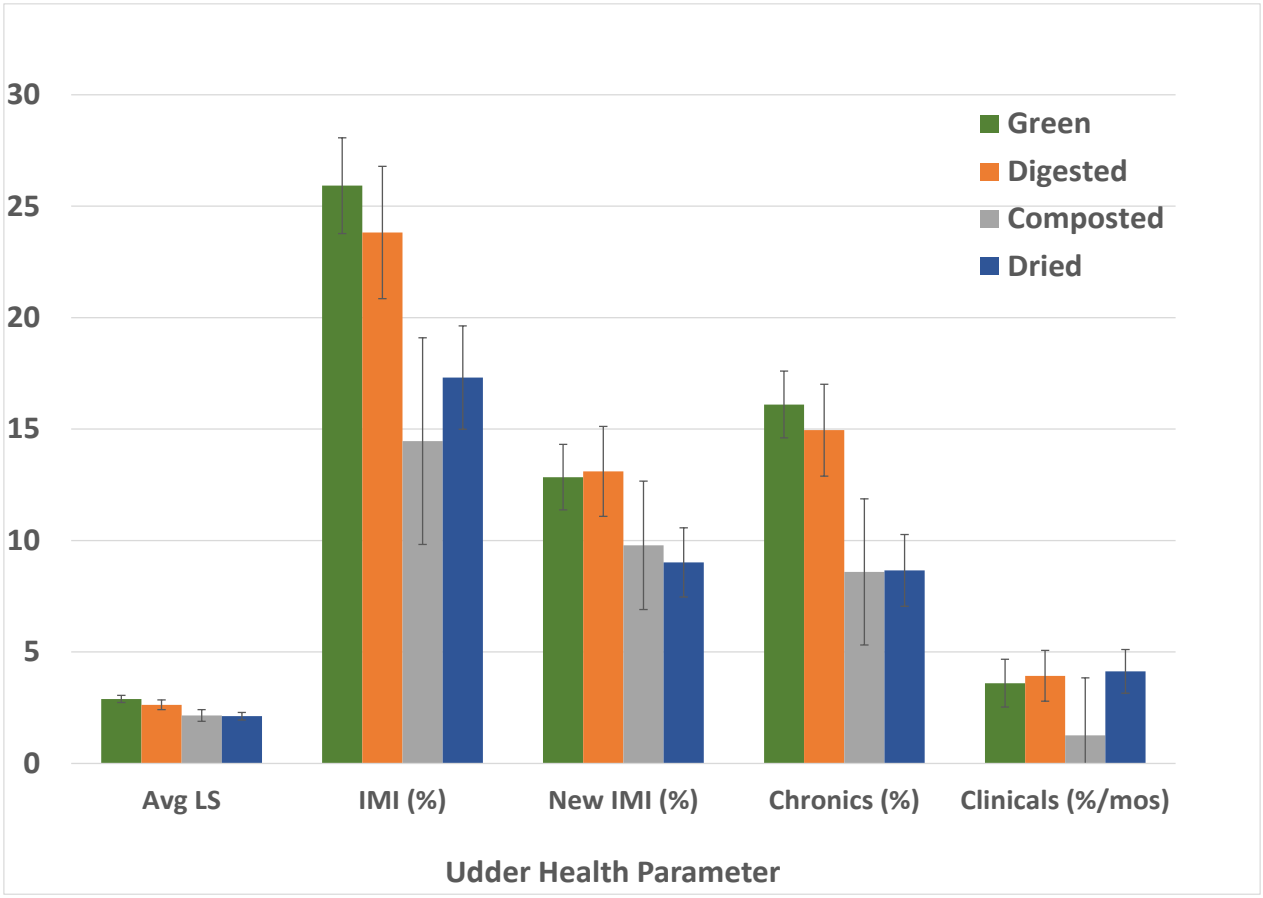
Klebsiella BBC lower in Dried, Composted and Digested (vs Green)

SSLO lower in Composted and tended lower in Dried (vs Digested or Green)

Staph – no treatment effect, though numerically lower in Dried RMS




Udder Health in Herds using Different RMS Processing Methods



Herds using dried or composted RMS had (or tended to have) better udder health than Green or Digested solids:

- Avg LS
- IMI %
- Chronics %

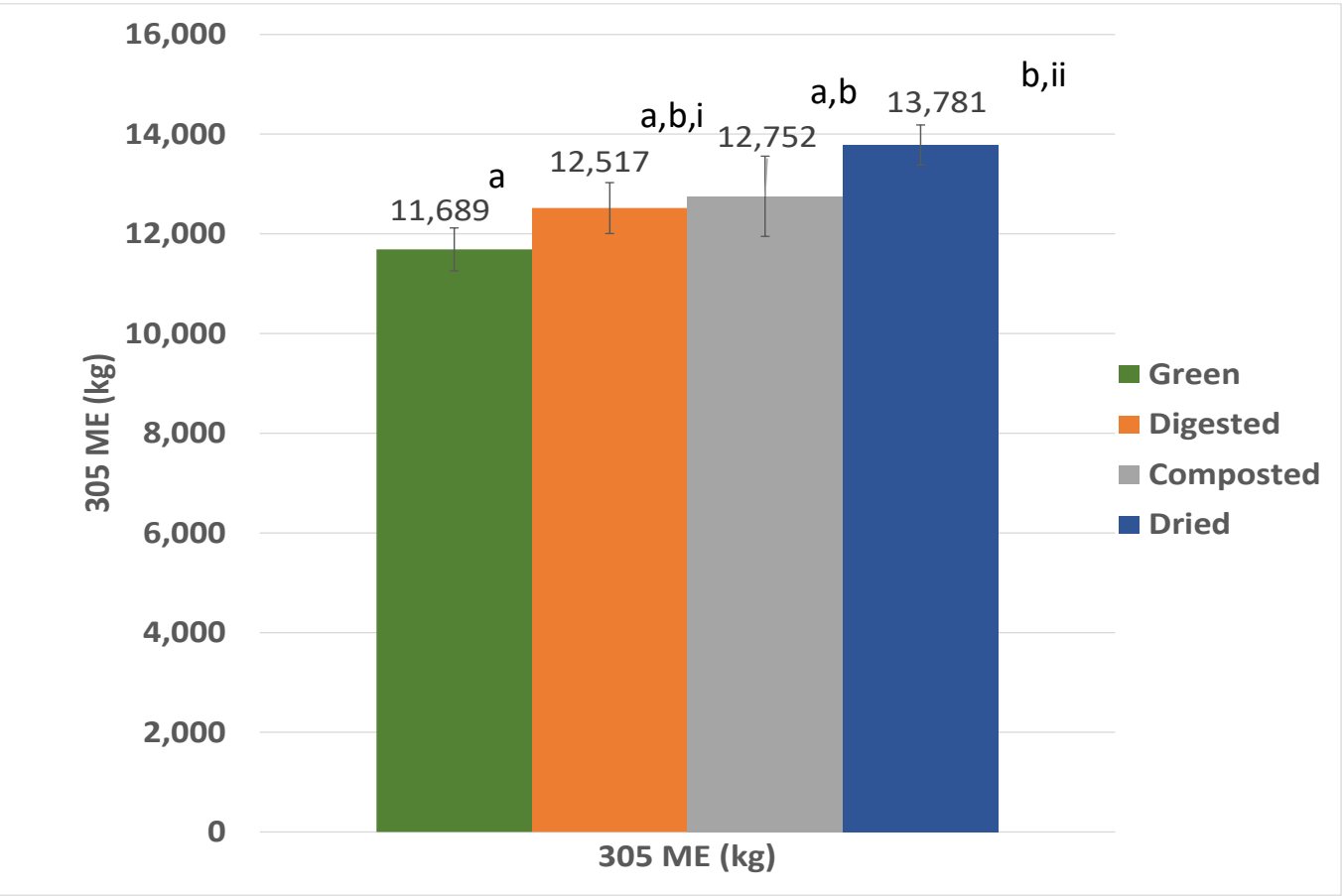
No processing effect for New IMI% or Clinicals%

No difference between…

- Dried vs Composted
- Green vs Digested




Milk Production in Herds using Different RMS Processing Methods



Herds using Dried RMS had higher production than Green RMS, and tended to have higher production than Digested RMS.

a,b: Signifcant at $P < 0.008$
i,ii: Significant at $0.008 \leq P < 0.1$




Summary of Study Findings

- What we know:
  - Primary separation of liquid & solids:
    - Some impact on DM%, but still too wet / doesn't reduce BBC
  - Additional processing methods:
    - Digesters: ↓ some pathogens / no clear udder health benefit
    - Dryers or composters: Greatest ↓ in BBC and ↑ udder health / milk yield
    - Heating is an important step to ↓ in BBC
- What we don't know:
  - Limited farm-scale studies / observational – more research needed
  - Cost-benefit analysis

Recycled Manure Solids (RMS) Bedding

- Monitoring and goals for RMS bedding characteristics
- Producing clean RTU RMS bedding
- Management in stalls

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Management of RMS in stalls

- Deliver fresh RMS to stalls ASAP after production/processing (< 24 hrs)

  Concern: bacterial proliferation in pile

Mclanahan.com

- Frequent (ideally daily) addition of fresh organic bedding to stalls

  Concern: Bacterial proliferation after 24 hrs plus fecal contamination in stalls

Manuremanager.com

Hogan & Smith, VCNA, 2012; Hohmann et al., 2020)

Bedding management in free stall barns (con't)

(Note: these are management basics that apply to any bedding material)

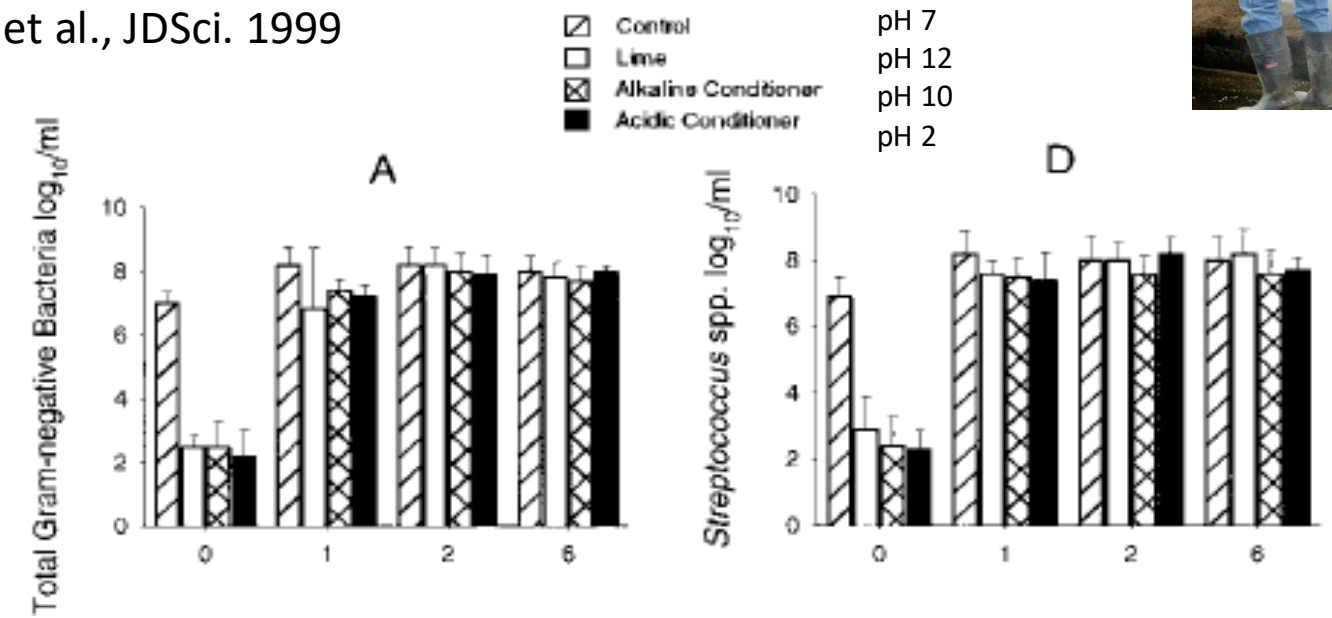
- Correct stall design & dimensions to avoid cows defecating/urinating in stalls
- Remove wet soiled bedding from back third of stalls at each milking
- Scrape alleyways at each milking
- Prevent standing water & manure in alleyways
- Avoid overcrowding: Less manure in alleyways
- Calm cattle handling
- Good ventilation
- Parlor management: pre/post-dip; prep routines; equipment function/settings; teat end condition,…

Lancasterfarming.com

Hogan & Smith, VCNA, 2012; Hohmann et al., 2020)

Use of Bedding Conditioners to alter pH?

Hogan et al., JDSci. 1999



- Conditioners reduce BBC for approx. 1 day – must add daily
- Studies lacking: Effects on udder health / economics / soil pH?

(Hogan et al.; 1999; Hogan et al., 2007; Godden et al., 2009; Hogan & Smith, 2012)

Sand Bedding

- Monitoring and goals for sand bedding characteristics
- Producing clean RTU sand bedding
- Management in stalls

Sand Bedding

New (virgin) Sand (NS)

Recycled Sand (RS)

Monitoring/Goals for Sand Characteristics

- Bedding Bacteria Counts (BBC)
- Organic matter (%)
- Dry matter (%)
- Particle size

Suggested Benchmarks for BBC in Sand Bedding

(Culture; cfu/cc wet bedding) (Patel et al., 2019)

Ready-to-use Sand Bedding (virgin or recycled)

Bacteria Group	Low	Moderate	High
Staph spp.	0	.	>0
Klebsiella spp.	0	.	>0
Coliforms	≤ 500	.	>500
SSLO (*Strep* spp.)	0	1 – 1,000	>1,000

Used Sand Bedding (from stalls)

Bacteria Group	Low	Moderate	High
Staph spp.	0	.	>0
Klebsiella spp.	0	.	>0
Coliforms	≤ 10,000	.	>10,000
SSLO (*Strep*. Spp.)	≤ 500,000	500,001 – 2,000,000	>2,000,000

Relationships between OM%, DM% and BBC in RTU Sand

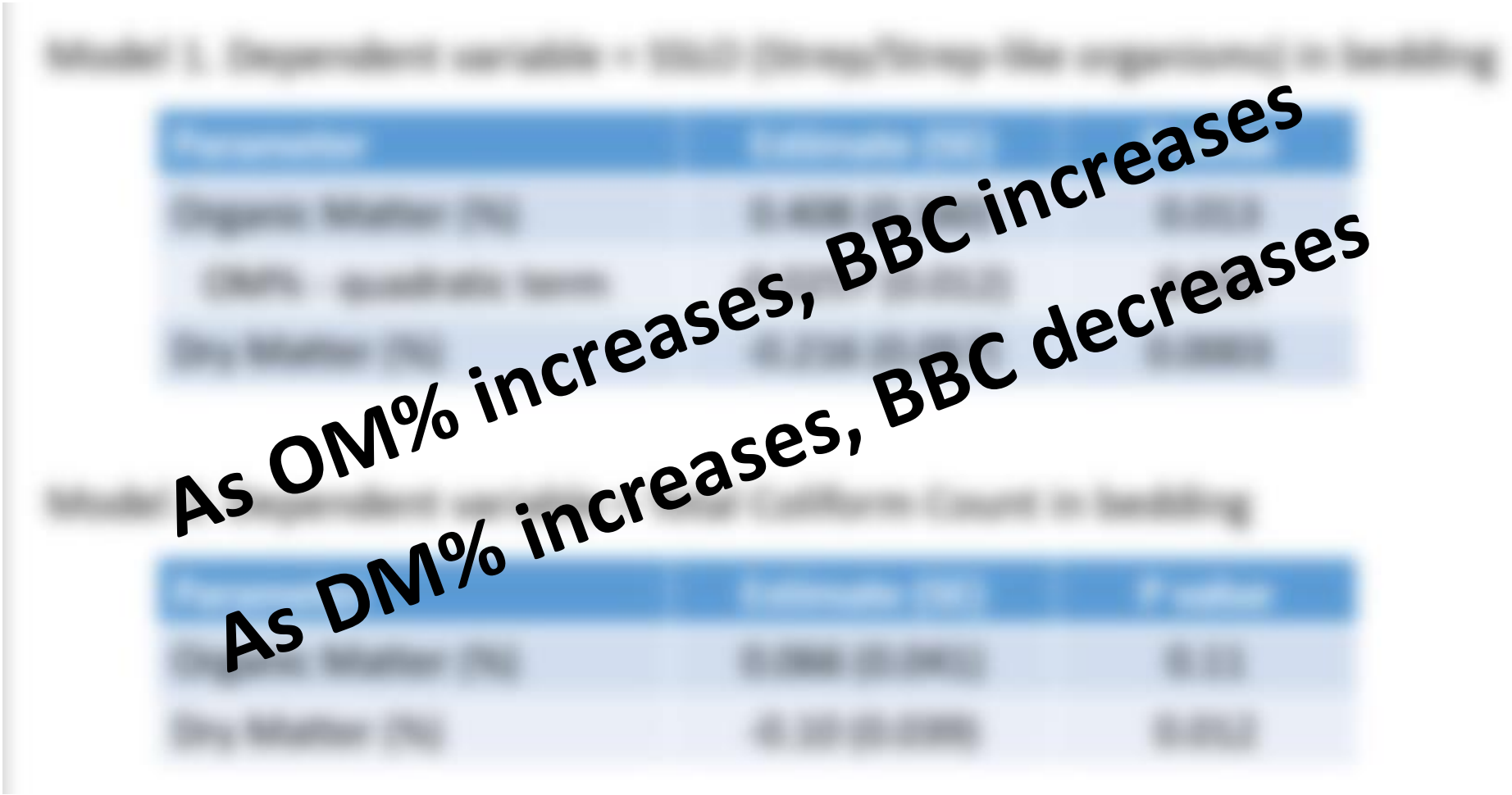
Model 1. Outcome variable = SSLO (Strep/Strep-like organisms) in bedding

Parameter	Estimate (SE)	P value
Organic Matter (%)	0.408 (0.160)	0.013
OM% - quadratic term	-0.0257 (0.012)	0.035
Dry Matter (%)	-0.216 (0.057)	0.0003

Model 2. Outcome variable = Total Coliform Count in bedding

Parameter	Estimate (SE)	P value
Organic Matter (%)	0.066 (0.041)	0.11
Dry Matter (%)	-0.10 (0.039)	0.012

Relationships between OM%, DM% and BBC in RTU Sand



As OM% increases, BBC increases

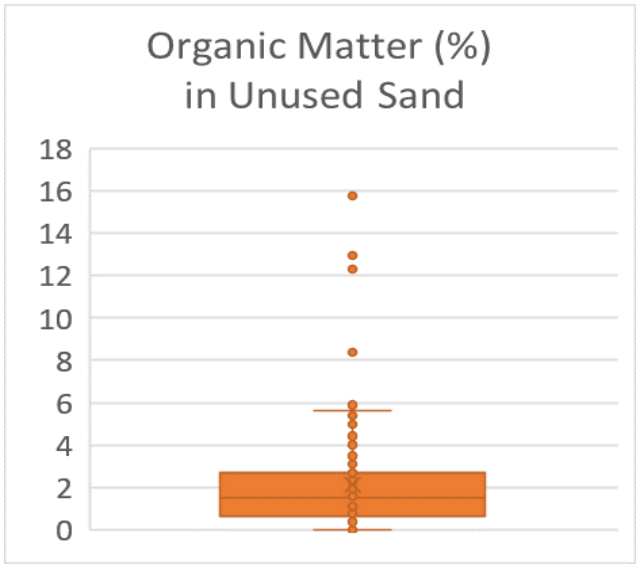
As DM% increases, BBC decreases

Establishing goals for OM% and DM% in RTU Sand Bedding

N=92

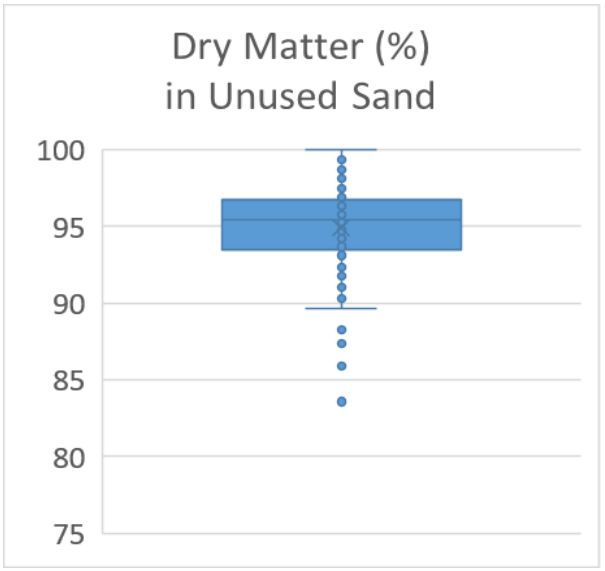
(Considers new/virgin and recycled sand together)

N=55



Median = 1.5% (0 to 15.8%)

New Sand = 0.9%
Recycled Sand = 2.4%



Median = 95.4% (83.6 to 100%)

New Sand = 96.1%
Recycled Sand = 93.5%

Goals: - OM ≤ 1.5% (36% of RS samples achieved this goal)
- DM > 95% (22% of RS samples achieved this goal)

Particle Size & Characteristics: Considerations in Selecting New Sand

C. Gooch, Cornell University

https://dairy-cattle.extension.org/sand-for-bedding-dairy-cow-stalls/

- Low OM%
- High DM%
- Texture: No debris or stones
- Appropriate & consistent size:
  - Too fine: Poor drainage, sticks to udder, compacts, harder to reclaim
  - Too course/sharp: Hoof health (C. Guard: Particle size < 3 mm)
  - Goal: > 80% of particles between 0.1 mm and 1.0 mm

2. Sand particles retained on mesh screens as a result of performing a sieve

Sieve Opening (mm)	% Finer than Sieve Opening: Certified Mason Sand	% Finer than Sieve Opening: Sand	% Material between these sieves
2.36	100.0	100.0	
1.00	96.0	100.0	
0.60	85.0	99.8	
0.30	57.0	97.8	74.7
0.13	22.0	25.3	
0.08	9.2	3.1	
Pan	2.0	0.0	

Example: sand bedding sieve Test results. QMPS lab (Ithaca, NY)

Summary: Goals for Monitoring Sand Characteristics

- Clean (low BBC) for both RTU and used (from stalls) sand
- Organic matter ≤ 1.5%
- Dry matter > 95 %
- Particle size:
  - Appropriate/consistent size
  - Avoid course/sharp edges

Sand Bedding

- Monitoring and goals for sand bedding characteristics
- Producing clean RTU sand bedding
- Management in stalls

Management to Produce Clean RTU Sand

- Sourcing
- Reclamation system / other processing
- Management of RTU sand
- Management of sand in stalls

Sourcing New (Virgin) Sand

- *Not all sand is the same*

Alternative uses for sand

- Descriptors of source:
  - Natural vs manufactured
  - Silica sand
  - Sugar sand
  - Concrete sand
  - Mason sand
  - …
- Descriptors of processing:
  - Washed sand: Removes clay, salt, dust, etc.
- Evaluate:
  - Particle size
  - OM? DM? BBC?

Reclamation and Processing:

Passive sand lane reclamation system

Reclamation & Processing: Mechanical Separators

McLanahan sand separator

- Claims > 90% sand recovered, DM ≈ 88%;
- OM% variable
- Requires storage time to dry out or secondary mechanical dryer

Stjernholm (cyclone) sand separator

- Claims 90-99% sand recovered, leaving slurry 'clean' enough for digester
- Single test: DM = 95%, OM = 1%
  (data from M. Misch. Stjernholm)
- Needs further evaluation

Managing OM% in mechanically reclaimed sand

- Regular system inspection and maintenance
- Increase wash water flow rate

Managing OM% in Passive Sand Lane Reclamation Systems

- Monitor total solids (TS %) in flush water (tip from S. Landwehr):
  - High TS:
    - Harbors bacteria
    - Interferes with piles draining/drying (especially for fine sand)
  - Goal TS < 3%
  - If TS > 5-7%, recharge flush water with clean water
  - Caution: don't get TS too low or:
    - More likely to freeze in winter
    - Some TS needed to carry sand forward through flume (less sand settling)
  - Recharge frequency varies by farm (monthly? Twice/year?)
  - Tips for TS testing:
    - Test in lab or with brix refractometer
    - Stick finger in the water:
      - If comes out slimy/syrupy with OM particles stuck to finger, it's time to recharge
      - If comes out wet/watery and with no OM particles, then probably is < 3% TS and still OK

Processing or management factors associated with DM% in unused sand bedding

Type	Parameter	Level	Estimate (SE)	P value
New (virgin) Sand	Prior washing	Washed	1.33 (0.59)	0.03
		Not washed	Ref	
	Storage time (d)		0.009 (0.006)	0.11
Reclaimed Sand	Covered storage	Shelter	1.61 (0.99)	0.12
		No shelter	Ref	
	Season	Summer	1.43 (0.59)	0.03
		Winter	Ref	
	Reclamation	Mechanical	-0.62 (0.95)	0.52
		Passive	Ref	

* No parameter tested was associated with OM% in unused sand bedding

Summary for managing DM% in ready-to-use sand

- New/virgin sand:
  - Washed sand?
  - Increased storage time
- Reclaimed sand:
  - Let stand / drain longer prior to reuse
  - Keep covered (avoid precipitation)
  - Consider investing in mechanical dryer (cost-benefit?)

McLanahan Rotary Sand Dryer

- Takes previously mechanically separated sand then further heats/dries it
- Rotary dryer: inlet temp 600°F / exit 180°F
- Efficacy and economics need study

Sand Bedding

- Monitoring and goals for sand bedding characteristics
- Producing clean RTU sand bedding
- Management in stalls

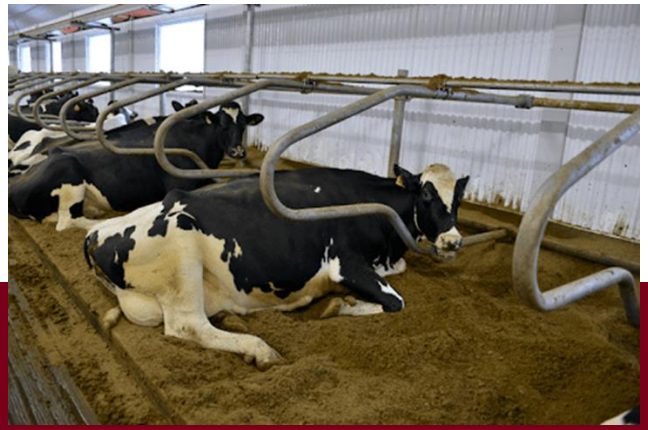
Managing sand in stalls

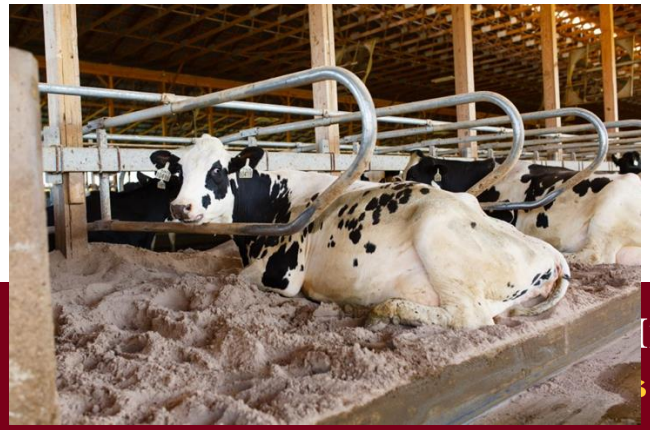
- Frequent addition of new bedding to stalls (daily or every second day ideal)
- Recc. 23 kg (50 lb)/cow/day *(M. Kristula, U Penn)*
- Have very dry sand available in Jan/Feb to prevent freezing in stalls
- Basics:
  - Remove manure pats/wet bedding from stalls and scrape alleyways at each milking
  - Keep stalls full and level
  - Proper stall dimensions to index resting cows to minimize defecation in back of stalls
- Periodic (e.g. annual?) complete removal of all bedding in back of free stalls (e.g. 1.5 feet deep / back 2 feet of stall) and replace with new sand bedding

Messer stall plow bedding extractor

Summary

- Bedding selection and management can have important impacts on mastitis/milk quality
- Principles of bedding management:
  - Select low risk bedding materials
  - Monitor bedding characteristics:
    - RMS: BBC, DM%
    - Sand: BBC, DM%, OM%, particle size/consistency
  - Sourcing and/or processing can help to produce clean RTU bedding
  - Management in stalls is important to keep bedding clean





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DMI DAIRY MANAGEMENT INC.™

UMASH Upper Midwest Agricultural Safety and Health Center

McLanahan

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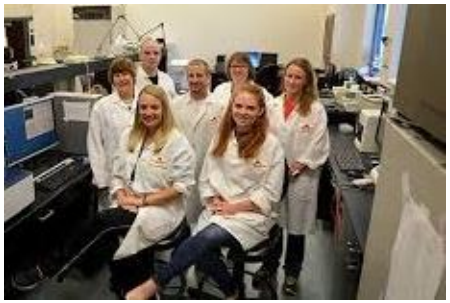

Lab for Udder Health


Thank you
Questions?