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Carry-over estimation based on ICAR farm test data

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ICAR Conference Prague 2019

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Agenda

- Motivation
- Carry-over
- Results from farm tests
- Criteria for a good test
- Statistical simulation
- Results
- Conclusion

Motivation

- „Whose milk is in the vial?“
  - Cow ID is important, but …
  - … milk in one vial might be from more than one cow, linking the vial to the „right“ cow might still not be that easy
- Milk samples are used for several types of lab diagnostics
- Having an idea about a milking system‘s carry-over allows estimating the usefulness of those lab diagnostics
- ICAR farm tests already provide data for milk yields and fat content – can those be used to estimate carry-over?

Carry-over

- Milk remaining in a milking system after a milking is finished gets mixed with the milk of the next cow
- Carry-over can be …
  - … absolute:
  - Remaining milk yield is always the same amount
  - Carry-over depends on milk yields of both cows
  - … relative:
  - Remaining milk is a percentage of the milk yield
  - Carry-over does not depend on milk yields of both cows
- … and probably often is a mix of both

Carry-over determination (1)

- Color method
  - Have uncolored and colored milk available
  - Do milking sequences with alternating milk color, using the same color twice subsequently (e.g. yellow-yellow-white-white-yellow…)
- Fat content method
  - Have high- and low-fat-milk available
  - Do milking sequences with alternating fat content, using the fat content twice subsequently (e.g. low-low-high-high-low-…)

Carry-over determination (2)

- Use different milk yields for milkings to allow addressing milk yield dependency
- Start milking from a bucket into a bucket while also using the required sampling device
- Take samples from both buckets and from the sampler
- Analyse samples for color ratio / fat content ratio, respectively
- Done. Done?

Carry-over determination (3)

- Both methods require …
  - well trained staff
  - additional substances
  - possibly different devices for analysis
  - time
  - additional costs

→ → → If there is an easier way, we should try that first.

Estimating carry-over

- Linear mixed model
- Model observed fat content as a linear regression on observed fat content of the previous cow
- Milk yield as linear covariable
- Fixed sampler/device effect
- Include random cow effect

Estimating carry-over - results

Device	Farms	Meters/ samplers	Milking sequences	Cows	Carry-over estimate	P-value (t-test)	SE
AMS 1	2	4	8	180	0.03	0.5557	0.05
AMS 2	1	2	2	63	0.15	0.0628	0.08
AMS 3	1	1	2	77	-0.01	0.8326	0.05
CON 1	1	5	2	196	0.00	0.9615	0.01

- … but how reliable are these results?
- Actual carry-over is unknown, therefore a simulation is necessary to have a „true“ carry-over as a reference value

Criteria for a good test

- Statistical power:
  will my test setup be able to detect the carry-over effect if it actually exists?
- Standard error of estimation:
  is the confidence interval of the estimated carry-over suited to classify carry-over into categories referring to the usability of laboratory processes?

Statistical power

- Probability to reject a test‘s null hypothesis H_0 when the alternative hypothesis H_1 is true
- Detect an effect if it truly exists
- 50 % statistical power:
  - Guessing game
  - Rather flip a coin for the same result as spending a considerable amount of money
- Aim for a statistical power of at last 80 %

Statistical simulation setup (1)

- Aim is to simulate an ICAR farm test
- Create a data set with
  - Type of device: AMS or conventional milking system
  - AMS: 1 ams with 2 samplers per farm, at least 50 milkings per AMS and sampler combination
  - Conventional: 4 devices and samplers per farm, at least 40 milkings per device
  - 2 farms
  - group of cows per farm
  - sequence of milkings per milking time

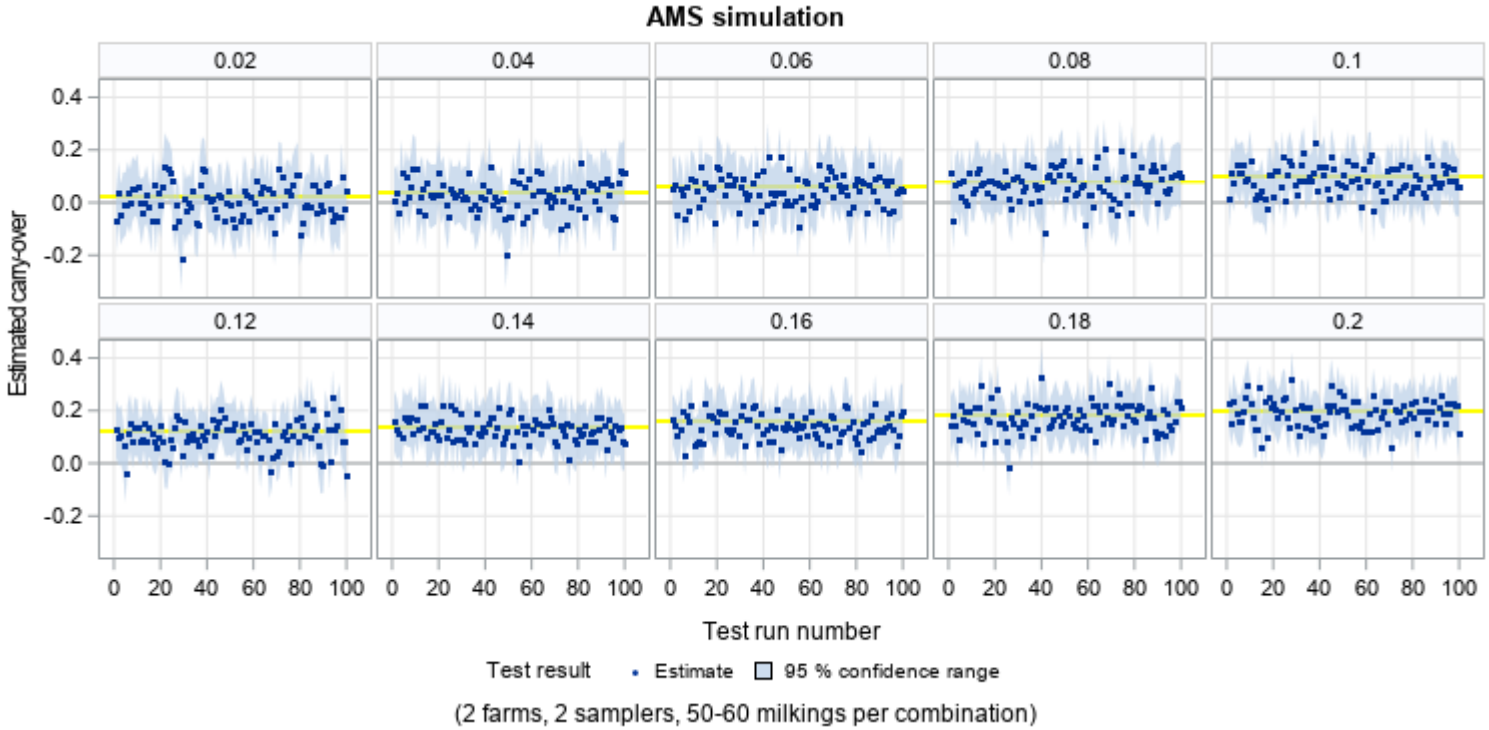
Statistical simulation setup (2)

- Create cows:
  - 16 years of MR data from a research farm
  - Four lactation levels: 1, 2, 3-5 and 6+
  - Four DIM levels: ≤ 95 d, ≤ 185 d, ≤ 305 d, > 305 d
  - Calculate mean milk yield and fat content per part
  - ~ 7,500 „cows“ to select from
- For AMS: milk flow required to calculate milking duration, allowing a cow to be milked again after 6 h

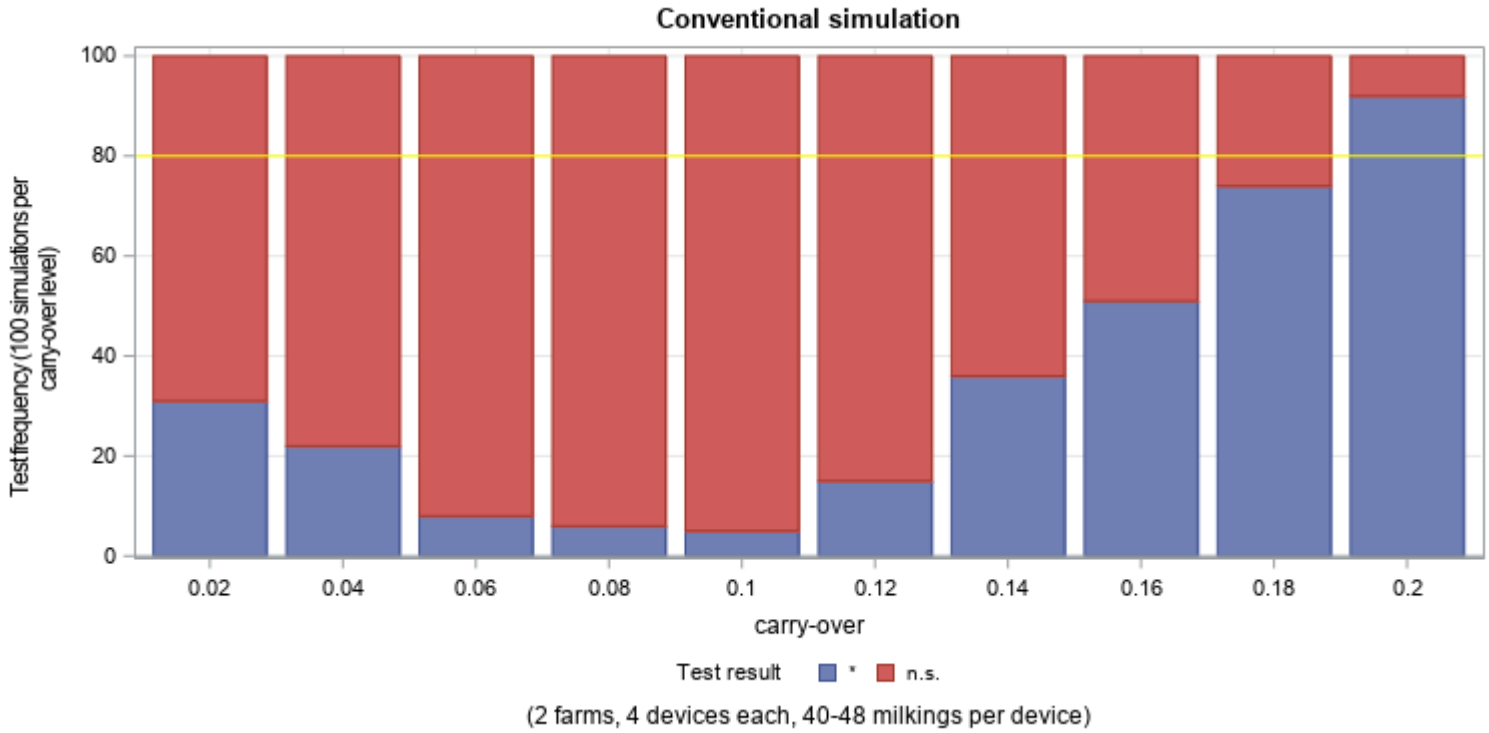
Statistical simulation setup (3)

- Create carry-over:
  - Schedule „true“ carry-over, include variation to get a distribution
  - Use milk yield and fat content distributions per cow in a milking sequence to calculate „true“ fat content for every milking
  - Calculate fat content in the sample based on those prerequisites
- Run statistical model for the farm test … 100 times

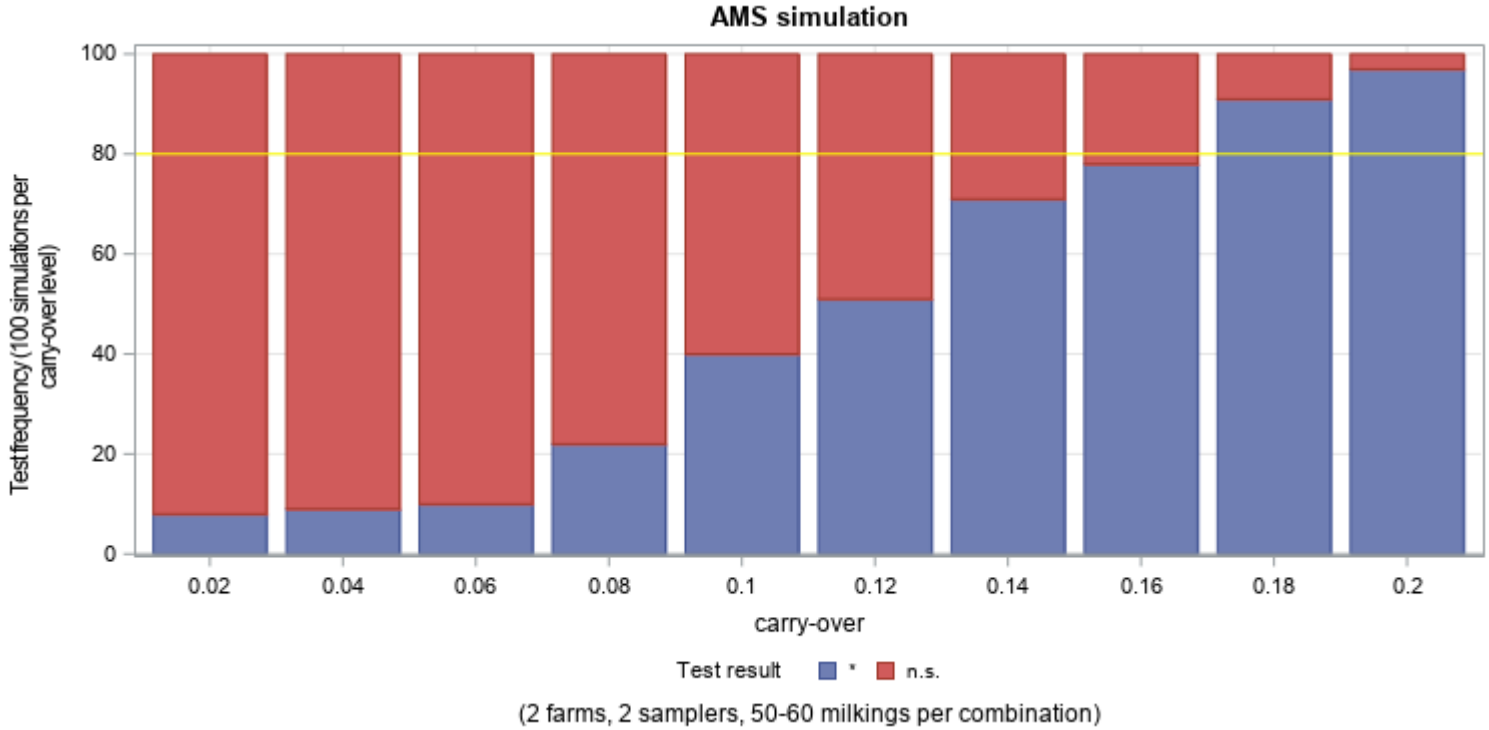
Results (1)


AMS simulation
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
Estimated carry-over
0.4
0.2
0.0
-0.2
0
20
40
60
80
100
Test run number
Test result
Estimate
95 % confidence range
(2 farms, 2 samplers, 50-60 milkings per combination)

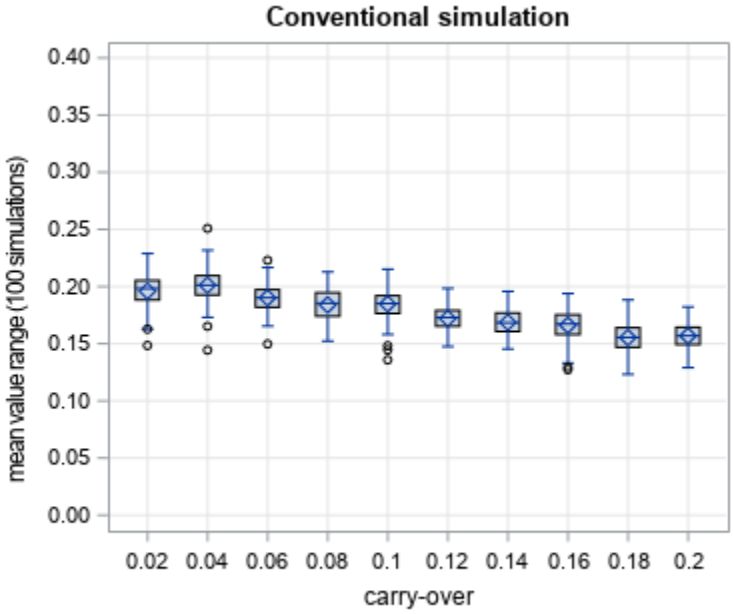
Results (2)


Conventional simulation
Test frequency (100 simulations per carry-over level)
100
80
60
40
20
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
carry-over
Test result
*
n.s.
(2 farms, 4 devices each, 40-48 milkings per device)

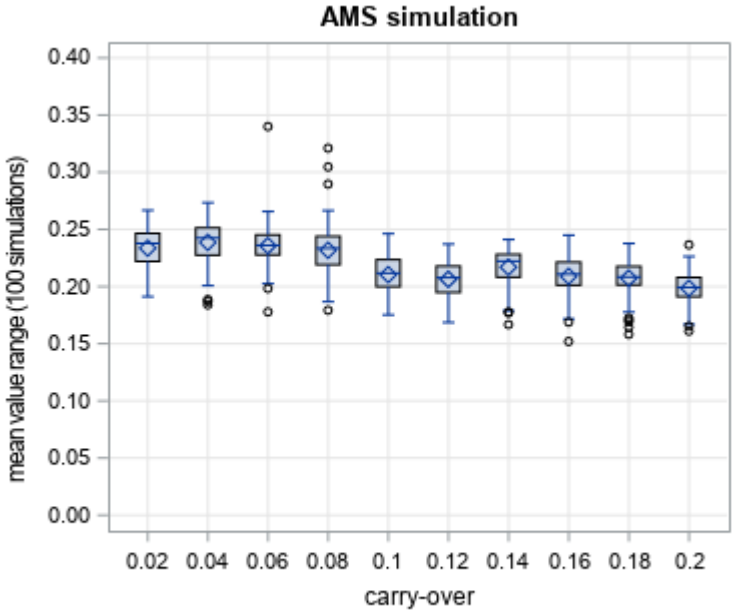
Results (3)


AMS simulation
Test frequency (100 simulations per carry-over level)
100
80
60
40
20
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
carry-over
Test result
*
n.s.
(2 farms, 2 samplers, 50-60 milkings per combination)

Results (4)



(2 farms, 4 devices each, 40-48 milkings per device)



(2 farms, 2 samplers, 50-60 milkings per combination)

Conclusions

- Based on the simulation results just using farm test data to estimate carry-over might not be the best idea right now
- Results show that there is still room for improvement:
  - Check milk yield, fat content and carry-over distributions
  - Check underlying statistical model
  - Use data from additional farm tests to improve assumptions
  - Carry out carry-over measurements to create reference values


Thanks for
your attention!