Production outcomes associated with hyperketolactia in dairy cows in Poland – how much it costs?

UNIVERSITY OF AGRICULTURE IN KRAKOW

PennState Extension

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Transition period is a challenge for a cow

Important challenges

1. Decrease in dry matter intake – lack of appetite
2. Increased requirements for
   a. energy
   b. Ca
   c. antioxidants
   d. protein (amino acids) ?
3. Stress

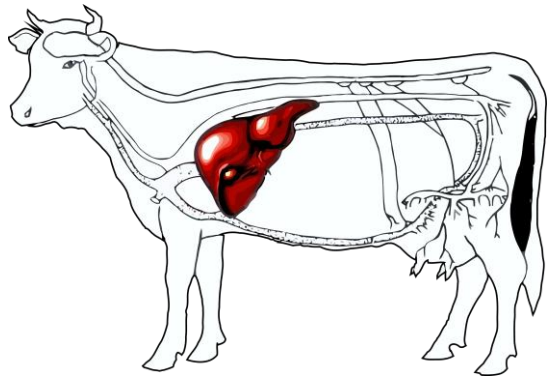
Metabolic consequences

1. Negative energy balance
   a. lack of glucose
   b. mobilization of reserves
2. Insulin-resistance
3. Hypocalcaemia
4. Excessive stress
5. Oxidative stress
6. Immunosuppression

Health consequences

1. Hypocalcemia
2. Ketosis
3. Fatty liver
4. Retained placenta
5. Mastitis, metritis, endometritis

Ketogenesis



Acetoacetic acid

Reduction driven by *dehydrogenase of BHB* *(BDH)*

NADH + H^+

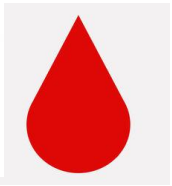
NAD^+

Spontaneous decarboxylation

CO_2

β-hydroxybutyrate (BHB)

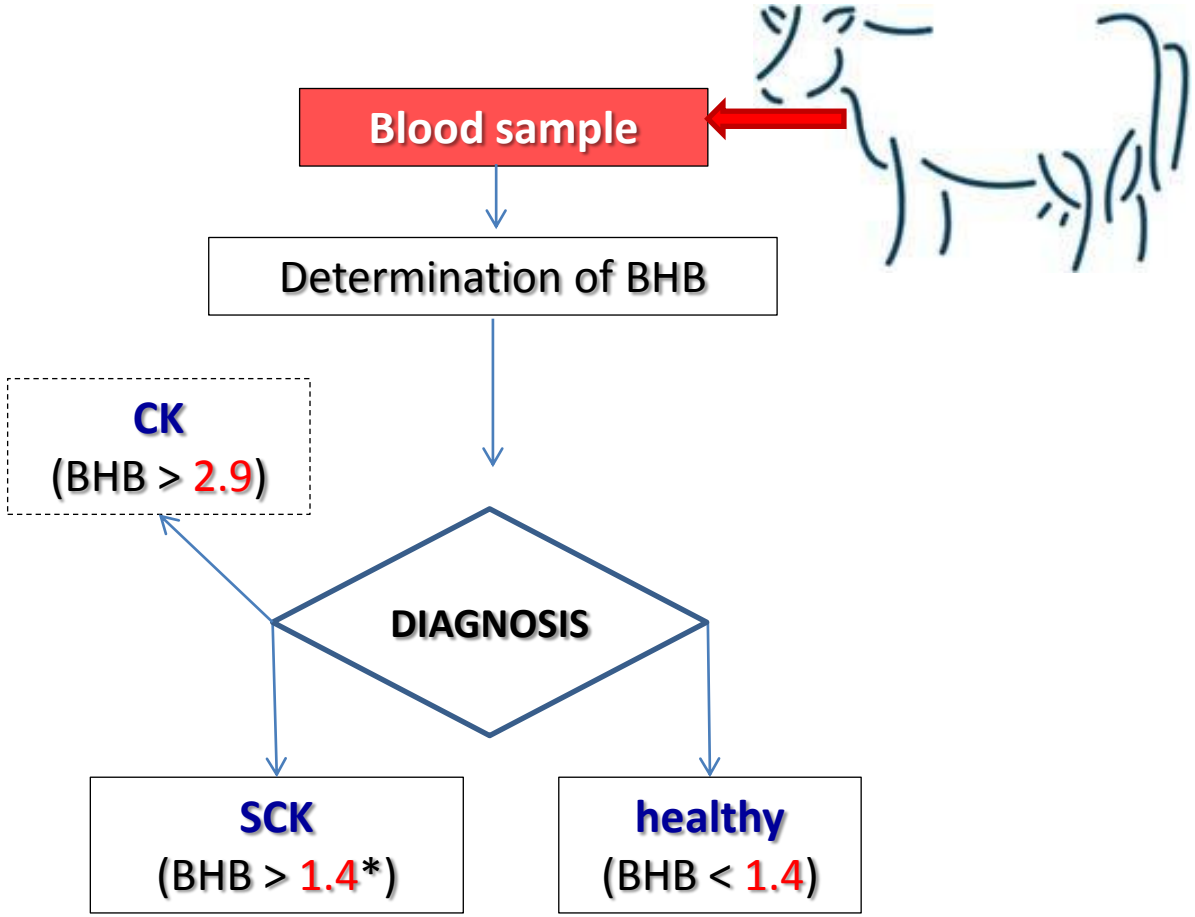
Acetone (ACE)



Hyperketonemia

Diagnosis of subclinical (SCK) or clinical (CK) ketosis

- … but what about acetone ?



Only BHB, not ACE !!!

*mmol/L; could be 1.2 mmol/L

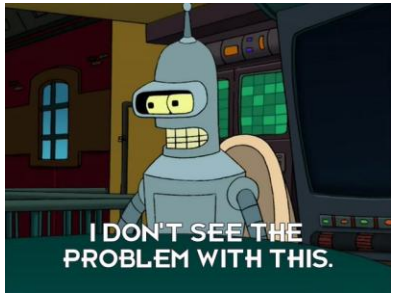
Acetone

- ustable in blood – not detectable by glucometer
- sufficiently stable in milk to be measured by FTIR technology
- is there any biological / production association of hyperacetonemia independent of BHB ?

Google

hyperacetonemia dairy cow → *4 results*

hyperketonemia dairy cow → *22,900 results*



Hyperketonemia vs. hyperketolactia

R = 0.66-0.96

Anderson, 1984; Enjalbert et al., 2001; Denis-Robichaud et al., 2014

↓

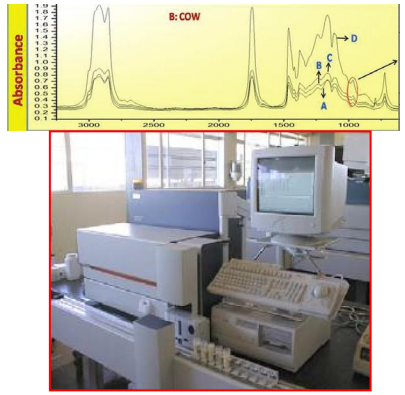
mBHB and mACE for diagnosing hyperketolactia in dairy cows

↓

chemical analysis of milk

R_{BHB} = 0.79
R_{ACE} = 0.85

de Roos et al., 2007



FTIR

↓

„may be not very high, but still usefull for screening the cow population"

mBHB and mACE, measured using FTIR spectroscopy, can be used in routine milk analysis (milk recording) to predict milk ketone bodies and to monitor hyperketolactia in dairy herds

Hyperketolactia

Polish Federation of Cattle Breeders and Dairy Farmers

CombiFoss FT+ using FTIR
(Foss Analytical A/S, Hillerød, Denmark)

- Non-invasive procedure
- This is not a snapshot – milk sample represents a period of time
- Under milk recording – cheap
- Possible monitoring of the herd

System of ketosis (hyperketoactia) monitoring in Poland

Polish Federation of Cattle Breeders and Dairy Farmers

Total number of dairy cows: 2 035 188

Total number of cows recorded: 792 963 (~37%)

Total number of herds recorded: 18 559

Average size of the herd: 42,8 cows

Average milk yield of cows recorded: 8 837 kg

2021-12-31

X – milk recording system labs with FTIR technology

System of ketosis (hyperketoactia) monitoring in Poland

- Monitoring of SCK in Poland
- Under milk recording system provided by PFHBiPM
- K! an index of SCK (Kowalski et al., 2014)
- First nation-wide program, introduced in 1-04-2013
- Monthly, we record cows within 6-60 DIM


ICAR
THE GLOBAL STANDARD FOR LIVESTOCK DATA
Via Savoia 78, 00198, Rome, Italy
CERTIFICATE OF QUALITY
Polish Federation of Cattle Breeders and Dairy Farmers
for Animal identification in dairy cattle; Production recording in dairy cattle; Laboratory service; Herdbook recording; Data processing
Hans Wilmink
President
Rome, 10 October 2016
Certificate number: 2016/02
Valid up-to: August 2021

PFHBiPM

POLSKA FEDERACJA HODOWCÓW BYDŁA I PRODUCENTÓW MLEKA

PFHBiPM

System of ketosis (hyperketoactia) monitoring in Poland

Blood sample

Determination of BHB

DIAGNOSIS

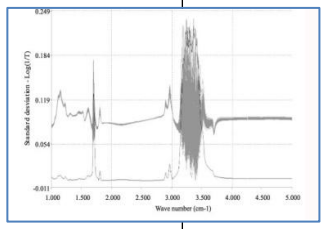
ill
(BHB > 1.4*)

healthy
(BHB < 1.4)

≠

Milk sample on test-day
Milk FTIR analysis

Parameters determined:
Fat [%]
Protein [%]
mBHB [mmol/L]
mACE [mmol/L]
……test-day..



ESTIMATION

ill
(assumption)

healthy
(assumption)

*mmol/L

Since 01-04-2013

- we have collected a lot of data
- we have learnt a lot about hyperketolactia among Polish cows in early lactation

What have we learnt

1. Concentrations of mACE and mBHB differ throughout early lactation

Hyperketolactia among Polish cows

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https://doi.org/10.3168/jds.2020-19734

Characterization of ketolactia in dairy cows during early lactation

Z. M. Kowalski,[1]* M. Sabatowicz,[1] J. Barć,[1] W. Jagusiak,[2] W. Młocek,[3] R. J. Van Saun,[4] and C. D. Dechow[5]

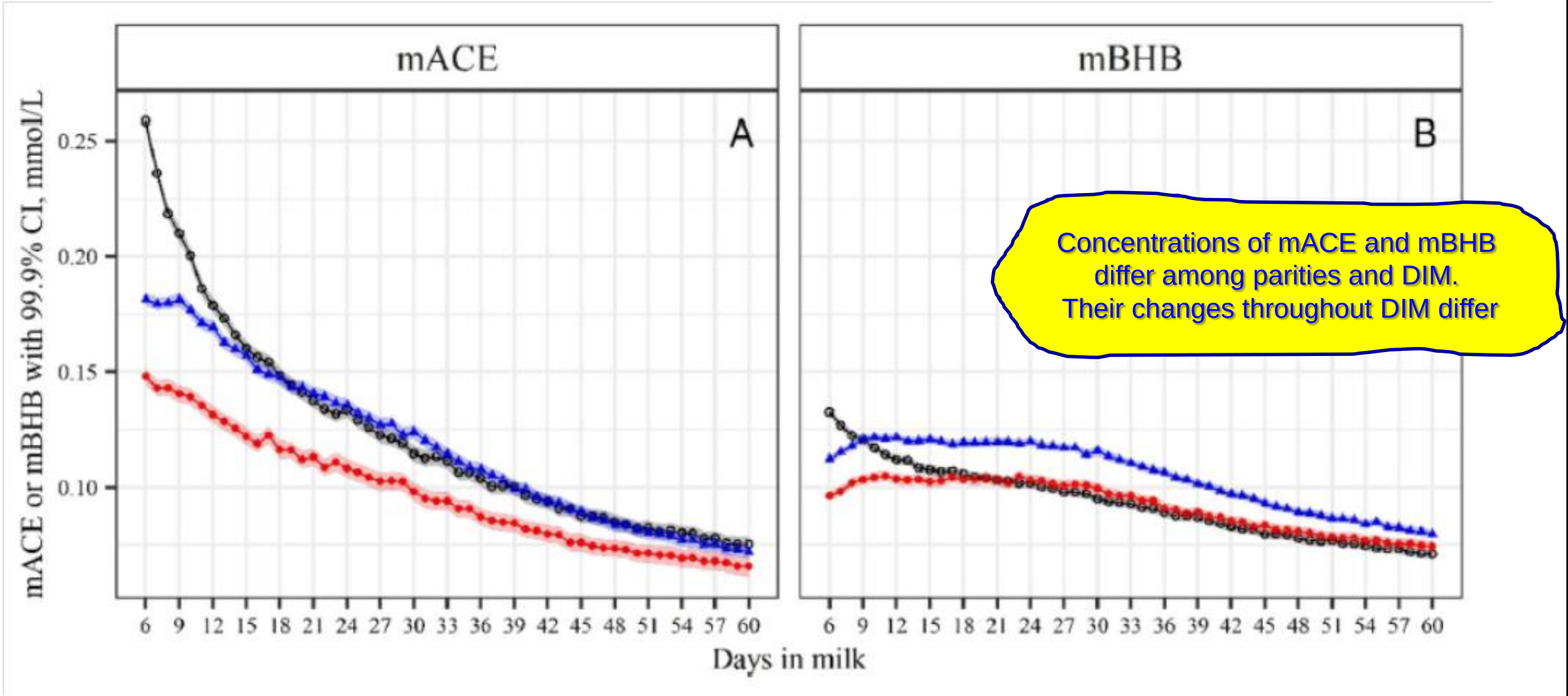
PFHBiPM

Polish Federation of Cattle Breeders and Dairy Farmers

- Data from milk recording system in Poland

- The data set consisted of > 3,8 M milk samples collected over a 4-yr period (April 1, 2013 to March 31, 2017),
  from ~ 21,300 dairy herds (from 1–1,356 cows per herd, average 38.7 cows/herd)

Hyperketolactia among Polish cows

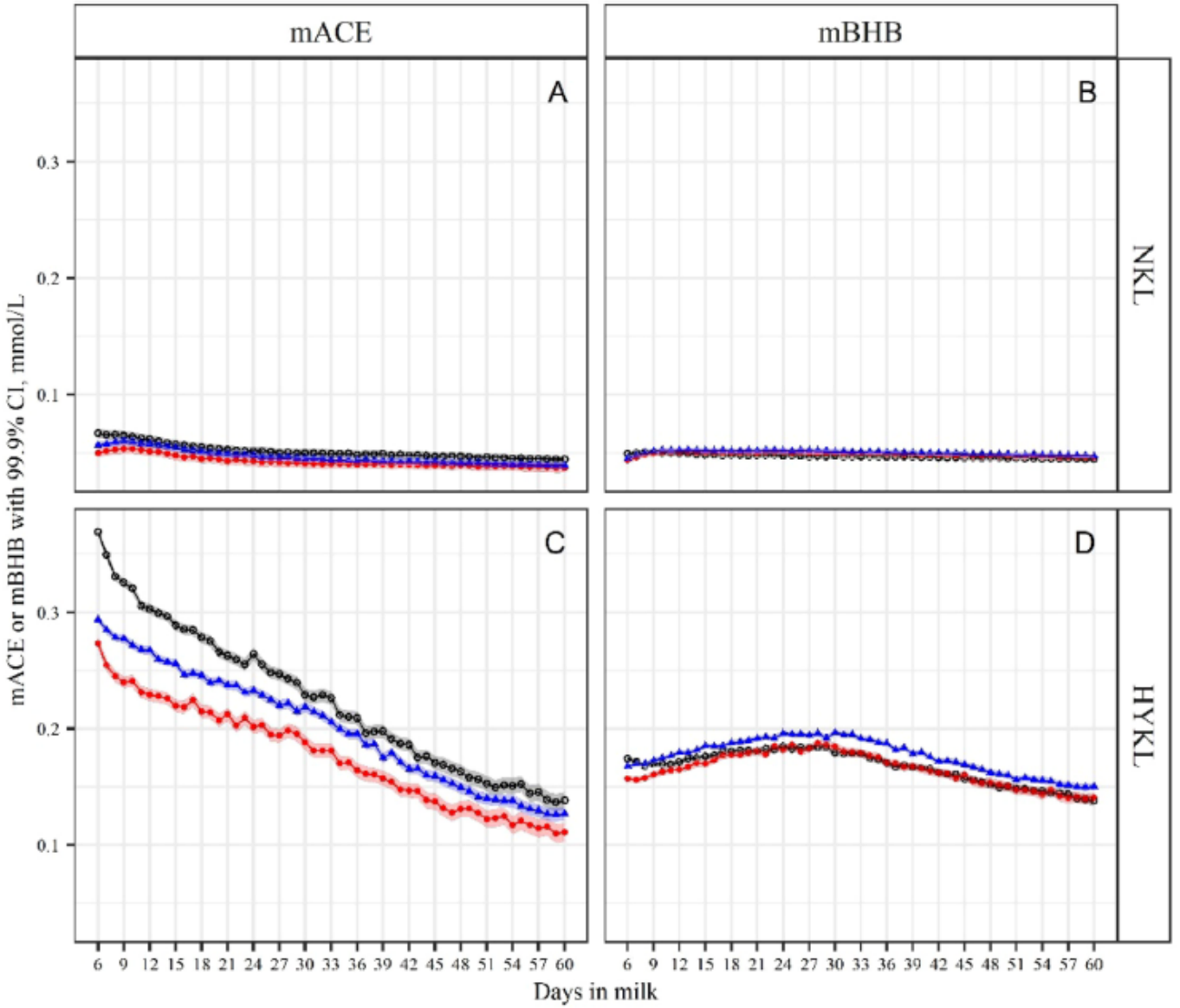


Least squares means of mACE (A) and mBHB (B) concentrations by parity (○ 1, ● 2, ▲ ≥3) and DIM (6–60 DIM)
Final model included effects of parity ($P < 0.001$), DIM ($P < 0.001$), and a parity × DIM interaction ($P < 0.001$).

Hyperketolactia among Polish cows

Normal (**NKL**):
mACE < 0.15 mmol/L and
mBHB < 0.10 mmol/L

Hyperketolactic (**HYKL**):
mACE > 0.15 mmol/L or
mBHB > 0.10 mmol/L



Why ?

2. There are different groups of ketolactia milk samples

   There is the acetone-alone type of hyperketolactia

Ketolactia groups

- Used thresholds of mACE ≥ 0.15 mmol/L and mBHB ≥ 0.10 mmol/L

  de Roos et al., 2007

- Ketolactia status groups
  - Normal (**NKL**): mACE < 0.15 mmol/L and mBHB < 0.10 mmol/L
  - Hyperketolactic (**HYKL**): mACE > 0.15 mmol/L or mBHB > 0.10 mmol/L
    - **HYKL$_{ACE}$**: mACE ≥ 0.15 mmol/L and mBHB < 0.10 mmol/L
    - **HYKL$_{BHB}$**: mACE < 0.15 mmol/L and mBHB ≥ 0.10 mmol/L
    - **HYKL$_{ACEBHB}$**: mACE ≥ 0.15 mmol/L and mBHB ≥ 0.10 mmol/L

Hyperketolactia

Table 3. Defined hyperketolactia status in milk samples collected in the 4-yr period from April 1, 2013 to March 31, 2017 from Polish Holstein-Friesian cows

Item	DIM		
	6–60	6–21	22–60
N milk samples	3,867,390	1,199,988	2,667,402
NKL, % of all samples[1]	67.7	57.0	72.4
HYKL, % of all samples[2]	32.3	43.0	27.6
From first-lactation cows, % of all from first-lactation cows	30.2	43.9	24.1
From second-lactation cows, % of all from second-lactation cows	28.2	36.2	24.6
From ≥third-lactation cows, % of all from ≥third-lactation cows	35.4	46.4	32.1
$HYKL_{ACEBHB}$[3]			
% of all samples	16.4	26.4	12.0
% of all hyperketolactic due to mACE or mBHB	50.8	61.3	43.4
$HYKL_{BHB}$[4]			
% of all samples	13.3	11.8	14.1
% of all hyperketolactic due to mACE or mBHB	41.3	27.4	51.0
$HYKL_{ACE}$[5]			
% of all samples	2.6	4.8	1.5
% of all hyperketolactic due to mACE or mBHB	7.9	11.3	5.6

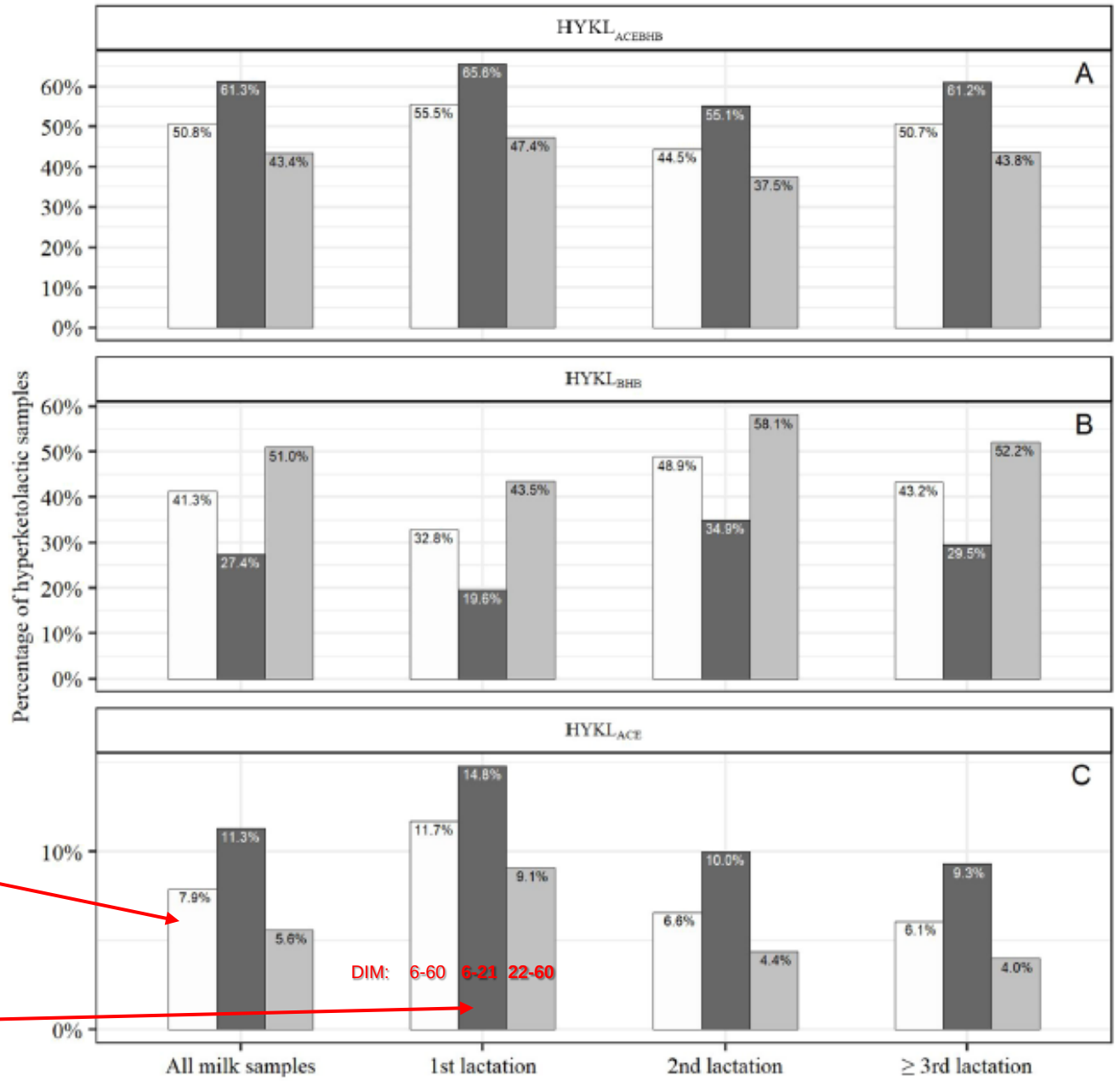
- 32.3% HYKL
- 43.0% within 6-21 DIM
  27.6% within 22-60 DIM

- 7.9% HYKL as $HYKL_{ACE}$
- 11.3% within 6-21 DIM
  5.6% within 22-60 DIM

Hyperketolactia

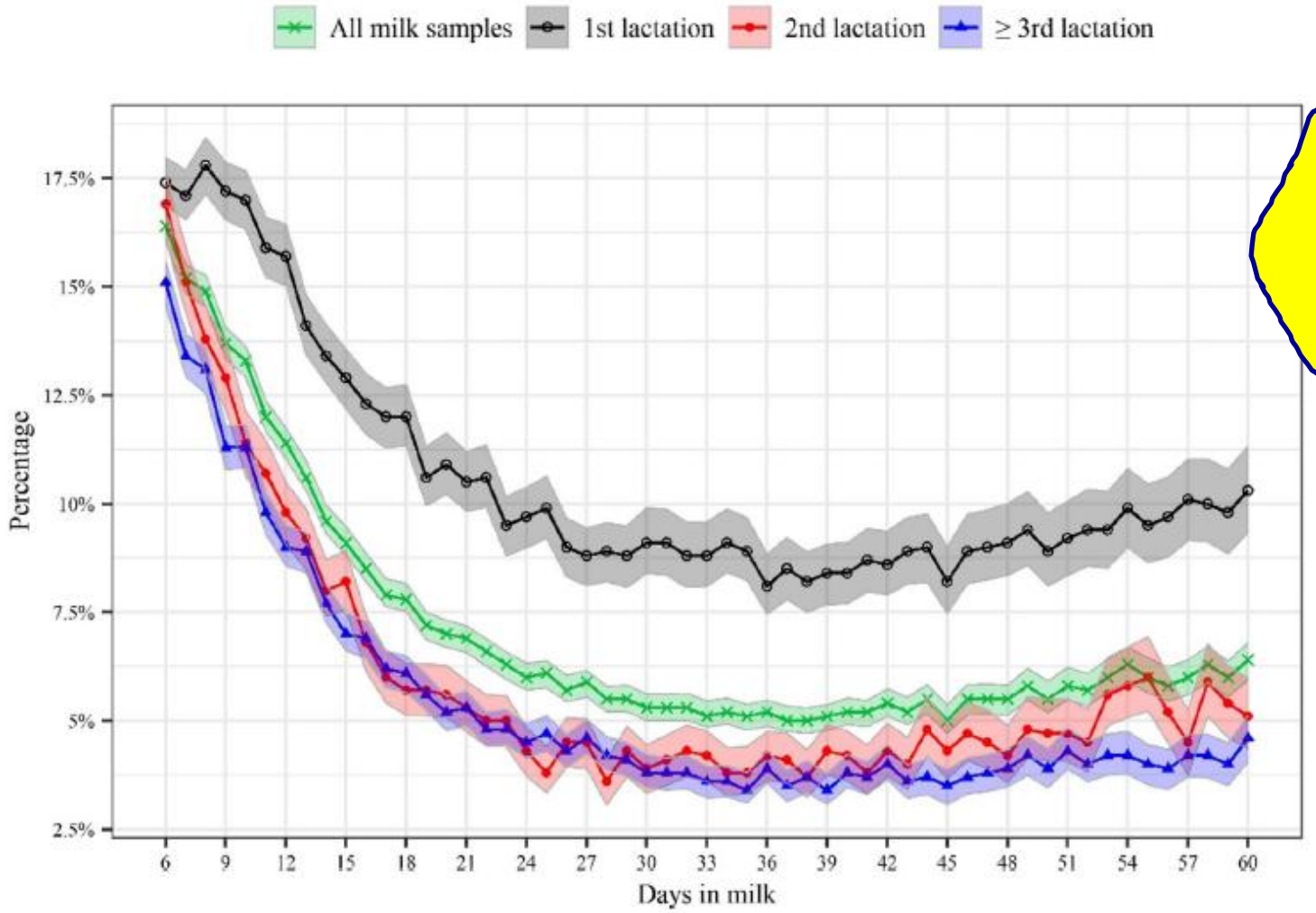
Using FITR spectroscopy ~8% of hyperketolactic milk samples had elevated mACE without elevated mBHB

Primiparous affected more than multipaorus cows,
especially in 6-21 DIM (~15%)



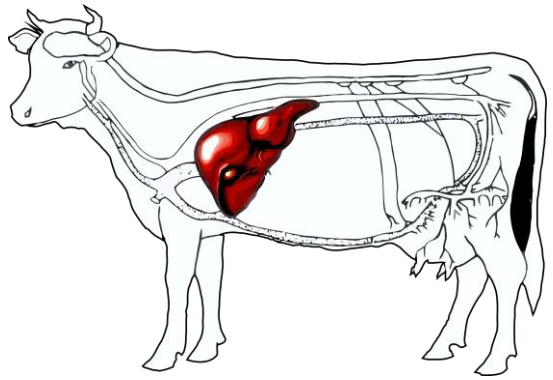
Hyperketolactia

$HYKL_{ACE}$ milk samples as % of HYKL in 6-60 DIM



- Considerable number of ketotic cows cannot be diagnosed by glucometer (acetone-alone type hyperketolactia; $HYKL_{ACE}$)
- Such a problem is more important in primiparous cows

Ketogenesis



Acetoacetic acid

Reduction driven by *dehydrogenase of BHB* *(BDH)*

NADH + H^+

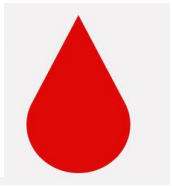
NAD^+

Spontaneous decarboxylation

CO_2

β-hydroxybutyrate (BHB)

Acetone (ACE)



- Why more cows in the first weeks of lactation ?
- Why more cows in the 1st lactation ?

3. Hyperketolactia is associated with lower milk production and altered milk composition

   The range of these negative relations depend on ketolactia group

ICPD 2022
JUNE 15 - 17
18th International Conference on Production Diseases in Farm Animals
Madison, Wisconsin

Study 1. – Objectives

Determine potential association of hyperketolactic status, defined by mACE and mBHB concentrations determined by FTIR spectroscopy, and parity (1, 2, 3+) with

- milk and energy corrected milk (ECM) yield,
- milk fat, protein, and lactose content and yield

within 6-60 DIM in early lactating Holstein dairy cows

Kowalski et al., submitted

Study 1. – Materials and Methods

- Retrospective study of milk sample data collected by Polish milk recording system
- ~5.0 M milk samples collected between 2014 and 2019 for Holstein-Friesen cows
- Censored samples having abnormal values for milk components (missing, too low or high)
- Ketolactia groups: NKL, $HYKL_{ACEBHB}$, $HYKL_{BHB}$, $HYKL_{ACE}$

Kowalski et al., submitted

Study 1. – Results

Overall means:

- Milk: 31.4 ± 9.1 kg/d
- ECM: 33.8 ± 9.9 kg/d
- Fat: 4.11 ± 0.96%
- Protein: 3.12 ± 0.36%
- Lactose: 4.78 ± 0.23%

Ketolactia Outcomes:

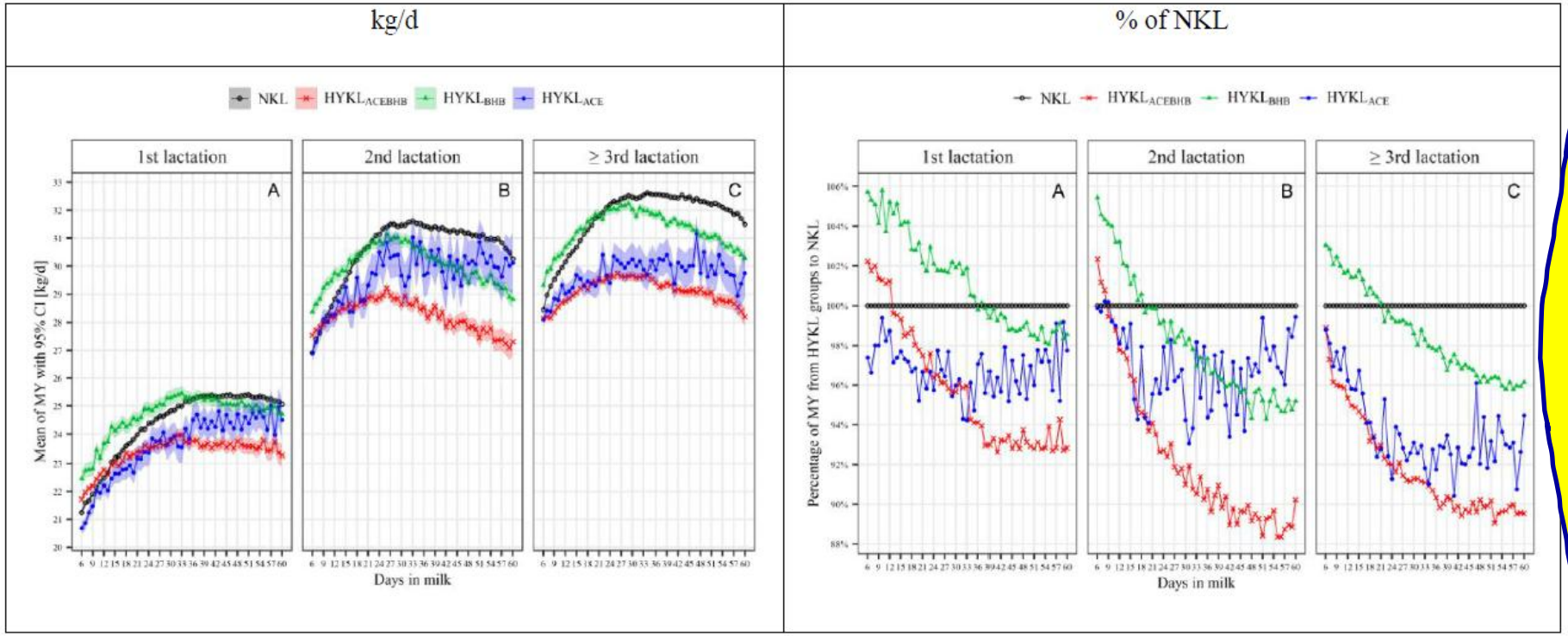
- 31.2% defined as HYKL
- 52.6% $HYKL_{ACEBHB}$
- 39.6% $HYKL_{BHB}$
- 7.8% $HYKL_{ACE}$
- 11.7% $HYKL_{ACE}$ in primiparous cows

Irrespective of parity or DIM, ketolactia groups differed for all traits studied (P<.001)

Kowalski et al., submitted

Study 1. – Results

Milk Yield

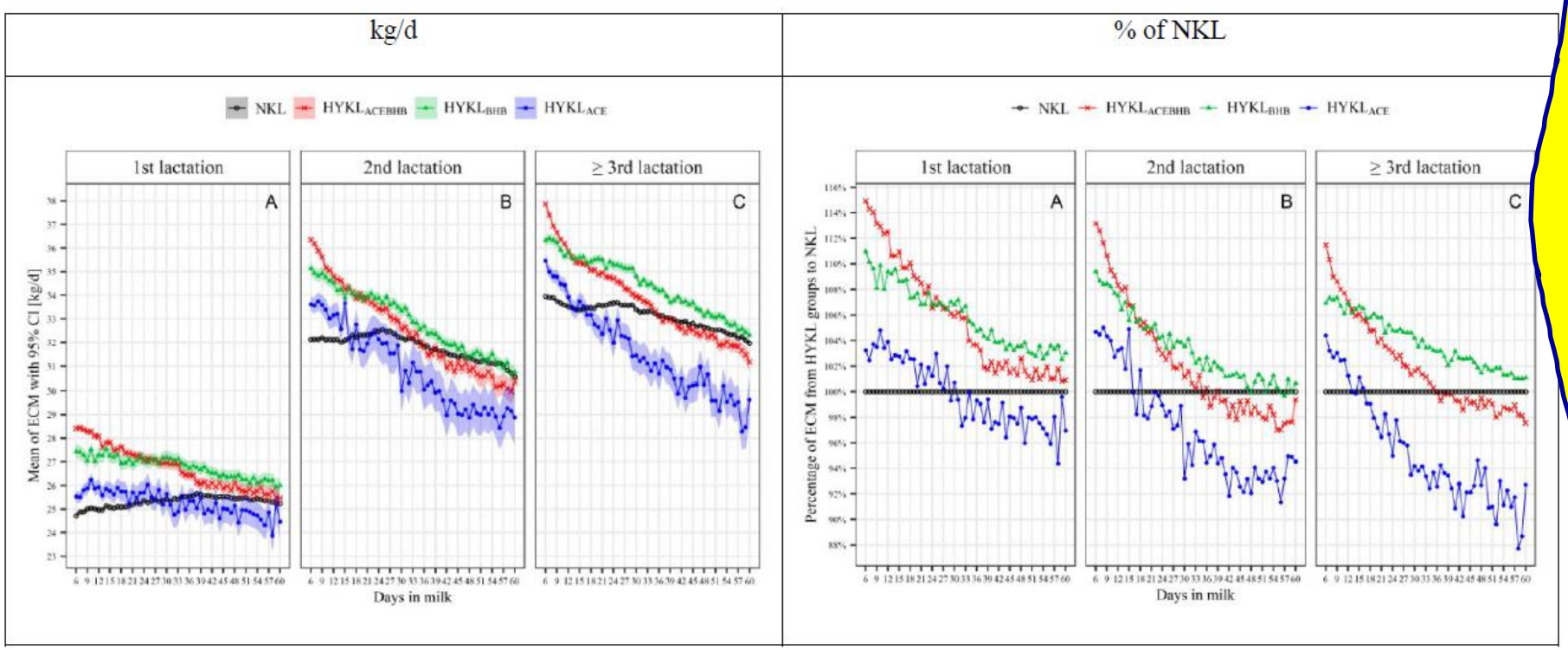


- Hyperketolactia is associated with lower milk yield irrespectively of parity and hyperketolactia group
- *BHB-alone type hyperketolactia* (HYKL$_{BHB}$) is associated with higher milk yield than healthy cows in ~6-30 DIM
- Acetone-alone type hyperketolactia (HYKL$_{ACE}$) is associated with lower milk yield

Kowalski et al., submitted

Study 1. – Results

Energy-Corrected Milk Yield

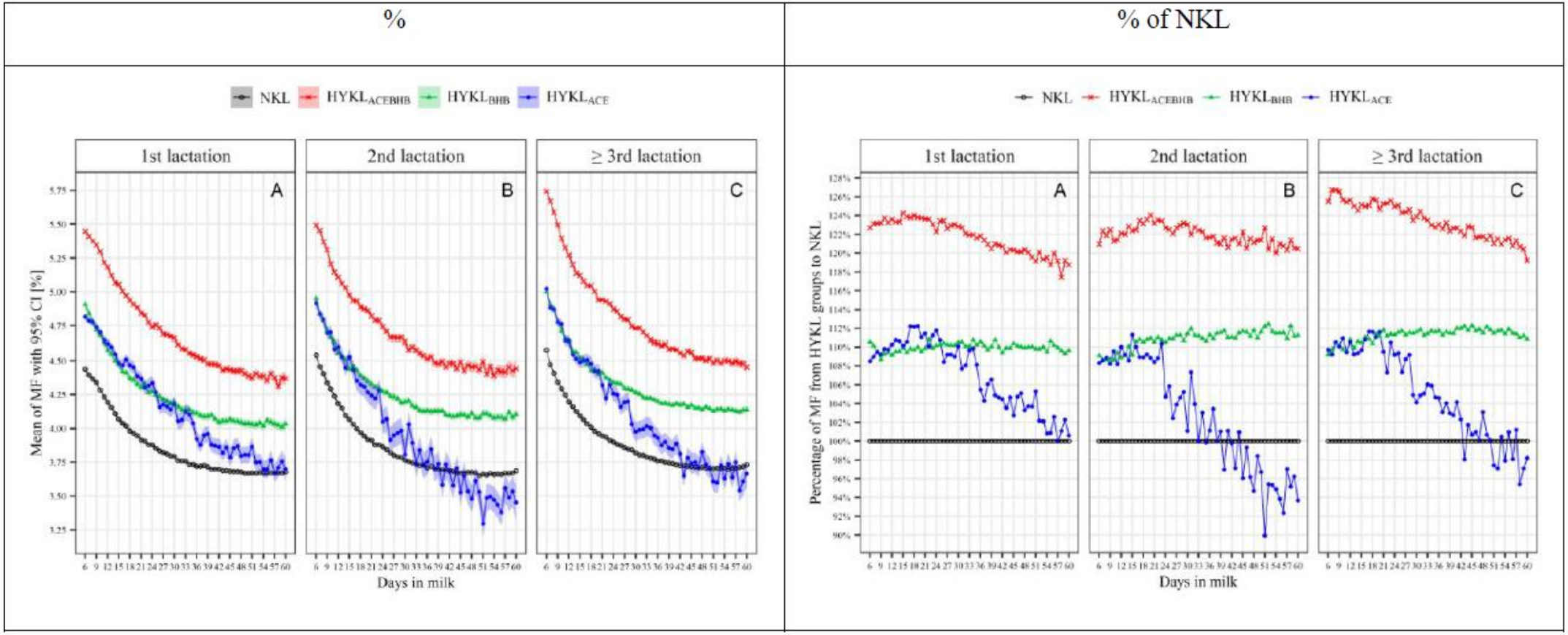


- Hyperketolactic cows, except HYKL$_{ACE}$ i HYKL$_{ACEBHB}$ in 30-60 DIM, produce more ECM than normal cows (NKL)
- Acetone-alone type hyperketolactic cows (HYKL$_{ACE}$) have lowest ECM yield; from 10-20 DIM they produce less ECM than normal cows

Kowalski et al., submitted

Study 1. – Results

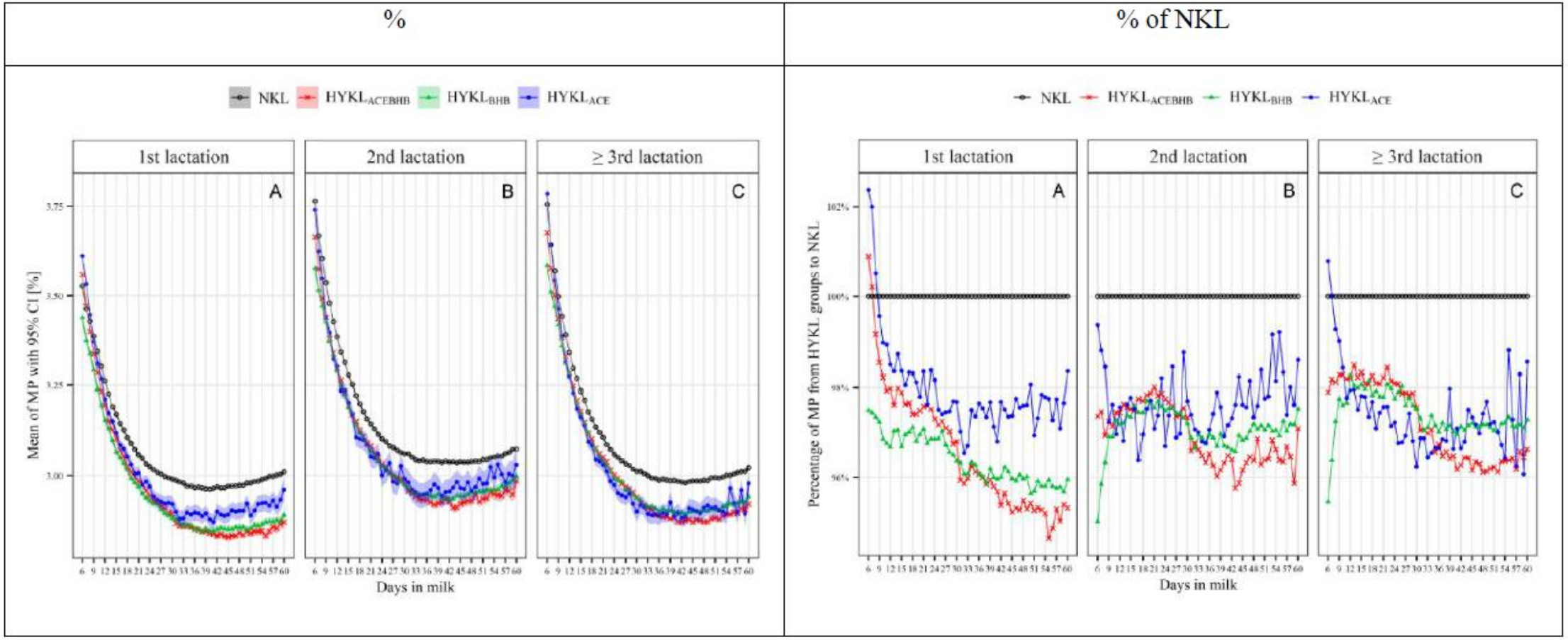
Milk Fat Content



Kowalski et al., submitted

Study 1. – Results

Milk Protein Content



Kowalski et al., submitted

Study 1. – Conclusions

- Hyperketolactia is associated with lower milk production and altered milk composition irrespective of parity
- Range of these relations depend on ketolactia status addressing both milk BHB and ACE concentrations
- Milk samples with both elevated ACE and BHB concentrations ($HYKL_{ACEBHB}$) are related to greatest negative productive responses
- Elevated mACE without elevated mBHB milk samples ($HYKL_{ACE}$) originate from lower performance cows compared to NKL samples suggesting some altered metabolic status associated with ACE

4. Time of hyperketolactia occurence matters

ICPD 2022
JUNE 15 - 17
18th International Conference on Production Diseases in Farm Animals
Madison, Wisconsin

Study 2. – Objectives

Determine the relations of time of hyperketolactia detection (first or second test-day) in early lactating Polish Holstein cows with production and reproduction outcomes

Kowalski et al., to be submitted

Study 2. – Materials and Methods

- Retrospective study of milk sample data collected by Polish milk recording system
- ~5.0 M milk samples collected in 2014-2019 from Holstein-Friesen cows
- Censored samples having abnormal values for milk components (missing, too low or high)
- Ketolactia groups:
  - Normal (**NKL**): mACE < 0.15 mmol/L and mBHB < 0.10 mmol/L
  - Hyperketolactic (**HYKL**): mACE ≥ 0.15 mmol/L or mBHB ≥ 0.10 mmol/L

Kowalski et al., to be submitted

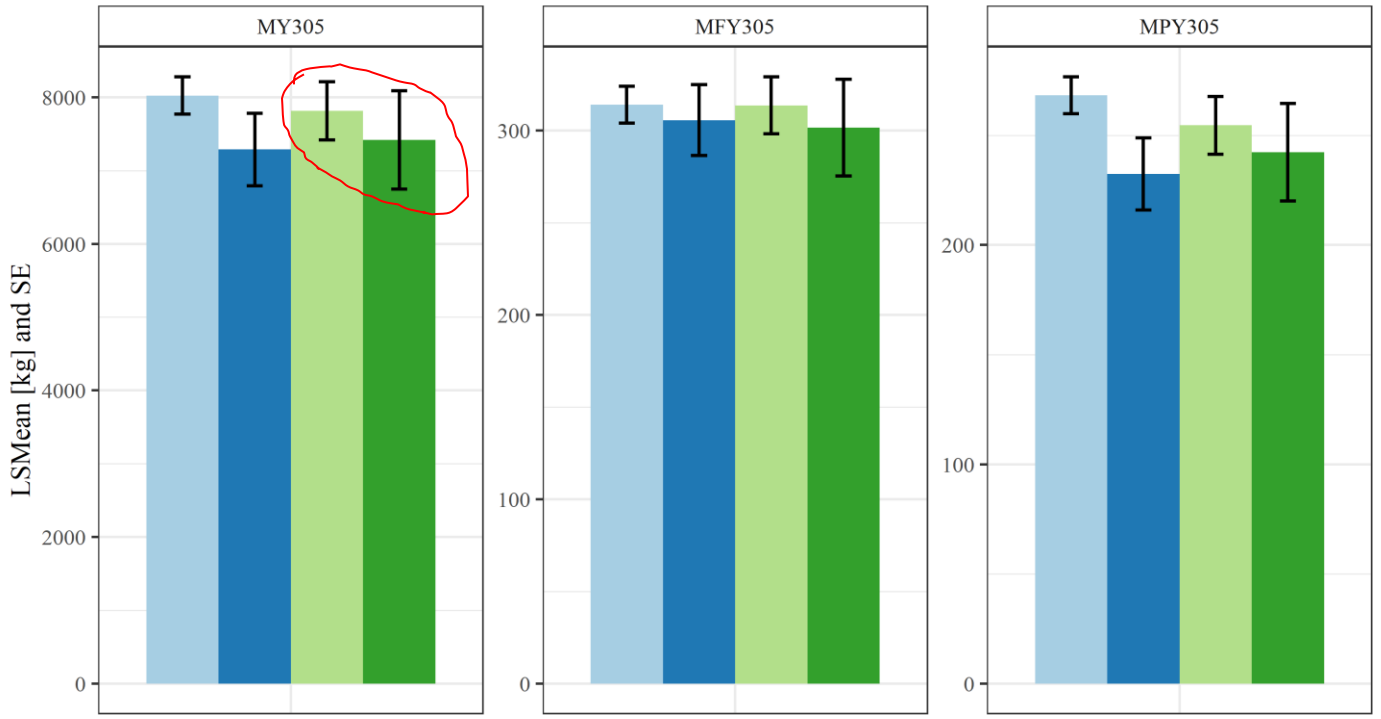
Study 2. – Materials and Methods

- Ketolactic status was determined on 1TD and 2TD, resulting in 4 categories:
  - nonelevated ketolactia on 1TD and 2TD (**NN**),
  - nonelevated ketolactia on the 1TD, and HYKL on the 2TD (**NH**)
  - HYKL on the 1TD, and nonelevated ketolactia on the 2TD (**HN**)
  - HYKL on the 1TD and 2TD (**HH**)

Kowalski et al., to be submitted

Study 2. – Results

Milk Yield, MF, and MP Yield in 305d lactation (kg)



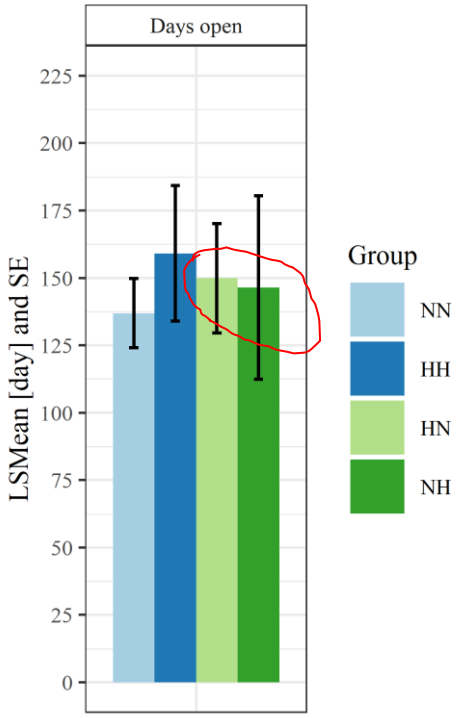
- The worst when HYKL on 1TD and 2TD (HH)
- HYKL on 2TD (NH) worse than on 1TD (HN)

$P < 0.001$

Kowalski et al., to be submitted

Study 2. – Results

Days open



- The worst when HYKL on 1TD and 2TD (HH)
- HYKL on 1TD (HN) worse than on 2TD (NH)

P < 0.001

Kowalski et al., to be submitted

Study 2. – Results

$HYKL_{ACE}$

Class	MY			ECM		
	1TD	2TD	3TD	1TD	2TD	3TD
NN	31.7	33.2	31.8	34.3	33.8	32.8
H_AN	29.2	33.0	31.9	33.7	33.2	32.4
NH_A	31.7	31.7	32.1	33.7	31.6	31.9
H_AH_A	29.5	31.1	31.3	33.1	31.4	31.3

- NN – Normal on 1st and 2nd TD
- H_AN – $HYKL_{ACE}$ on 1st TD and Normal on 2nd TD
- NH_A – Normal on 1st TD and $HYKL_{ACE}$ on 2nd TD
- H_AH_A – $HYKL_{ACE}$ on 1st and 2nd TD

- Acetone-alone type hyperketolactia ($HYKL_{ACE}$) is associated with decreased daily MY for 2-3 kg, but not ECM
- Earlier in lactation means worse… ???

Kowalski et al., to be submitted

Study 2. – Conclusions

- HYKL is associated with lower production outcomes, but the range of these negative relations depends on time of its occurrence

- HYKL occurring in the 2TD was more associated with lower MY and ECM yield than in the 1TD. Contrary, HYKL occurring in the 1TD, was more associated with poor reproduction

- ... but, $HYKL_{ACE}$ occurring earlier in lactation means worse… ???

Take home messages

- Concentrations of mACE and mBHB differ throughout early lactation
- There are different groups of ketolactia
- About 8% of hyperketolactic milk samples had elevated mACE without elevated mBHB. Primiparous cows, at 6-21 DIM are the most frequent (~15%)

Take home messages

- Hyperketolactia is associated with lower milk production and altered milk composition, but the range of these negative effects depend on ketolactia group

- Time of hyperketolactia occurrence matters – that occurring in the 2TD is associated with MY more than in the 1TD, but that occurring in the 1TD was more than that of 2TD associated with poor reproduction

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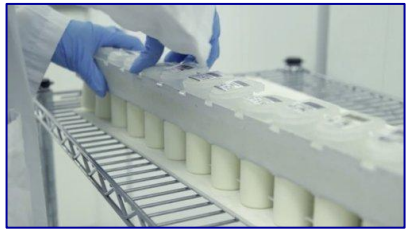

PFHBiPM

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Thank you for your attention !