



UNIVERSITY
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Polish Federation of Cattle
Breeders and Dairy Farmers

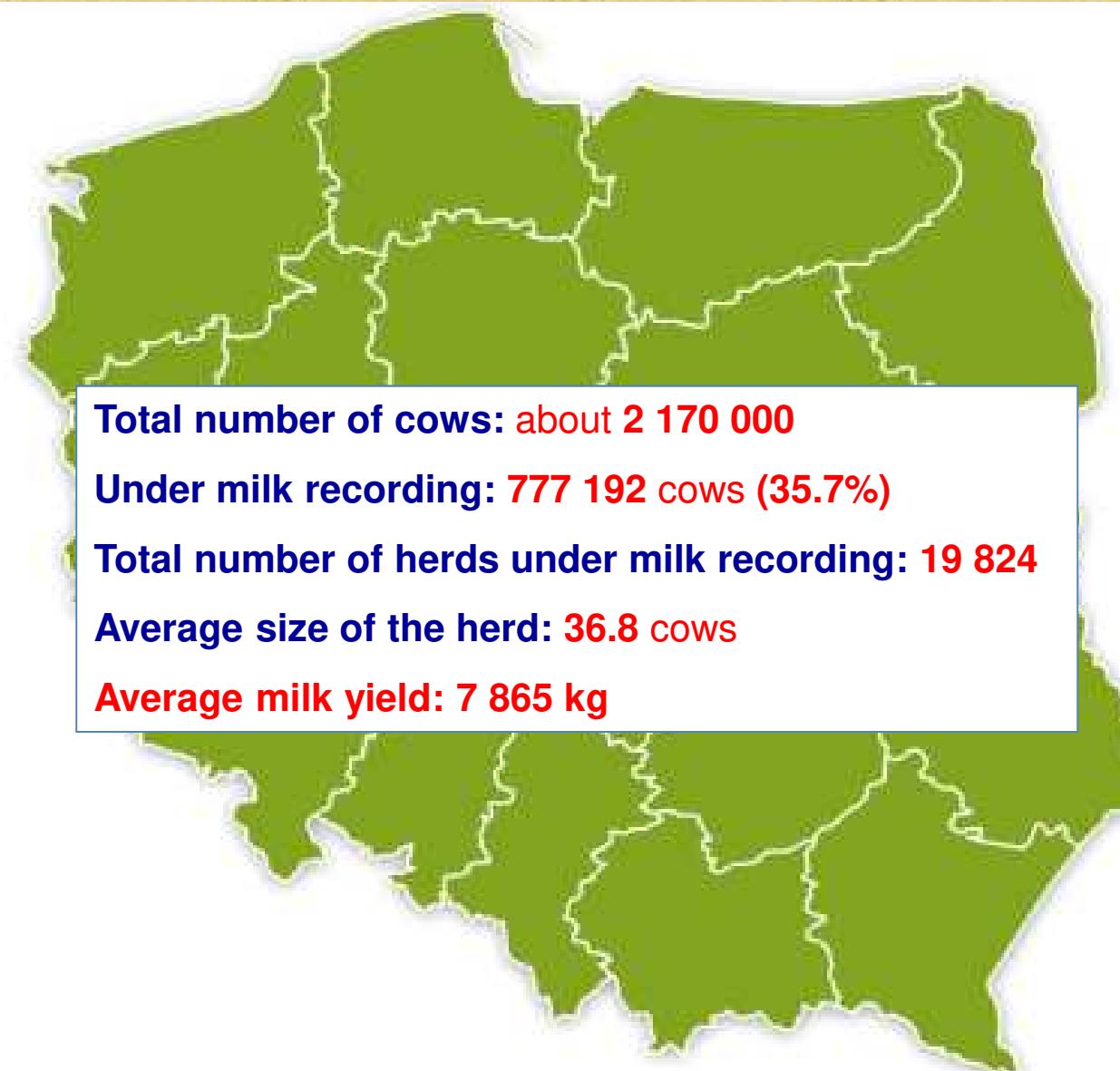
Risk factors for ketosis in dairy cows in Poland

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Important facts.....



Total number of cows: about 2 170 000

Under milk recording: 777 192 cows (35.7%)

Total number of herds under milk recording: 19 824

Average size of the herd: 36.8 cows

Average milk yield: 7 865 kg

2016-12-31

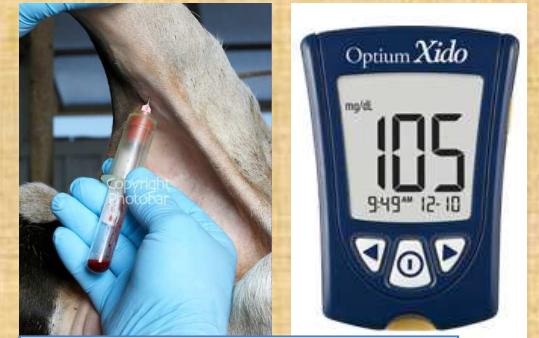
Different ketosis

Subclinical (SCK)

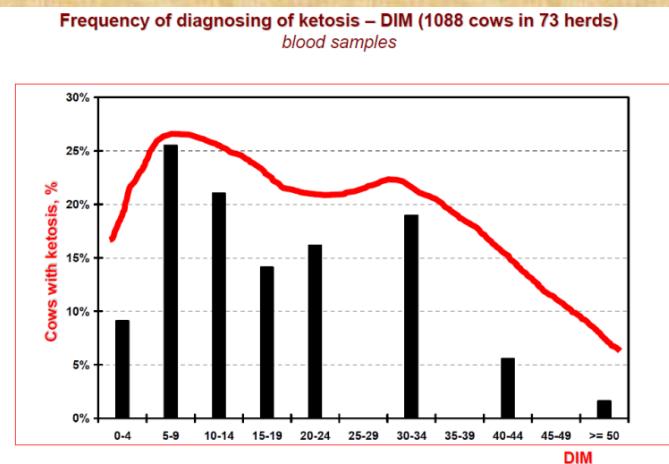
> 1.2 or > 1.4 mmol/L

Clinical (CK)

> 3.0 mmol/L



Type 2.
1 - 21 DIM



Oetzel, 2007

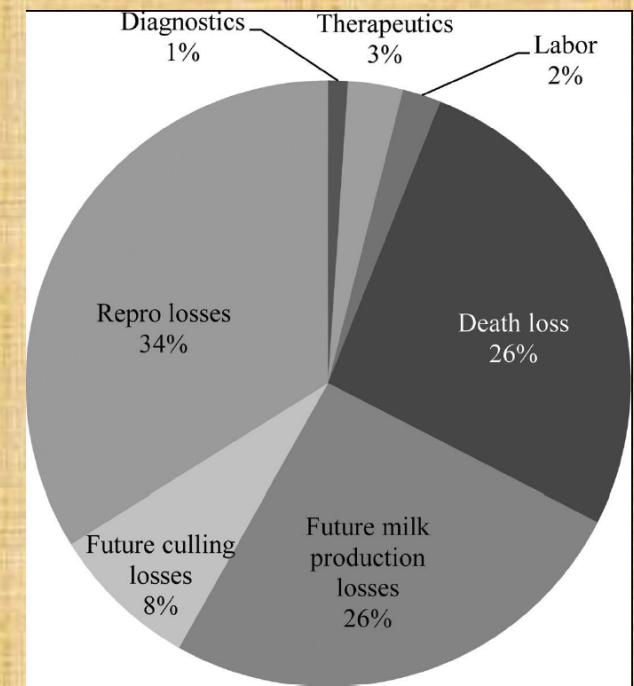


Type 1.
> 22 DIM



Consequences of ketosis

- Increased risk of other metabolic disorders (CK, LDA, RDA)
- Increased risk of infectious diseases (metritis, mastitis)
- Decreased milk yield
- Decreased reproduction performance
- Increased risk of premature culling

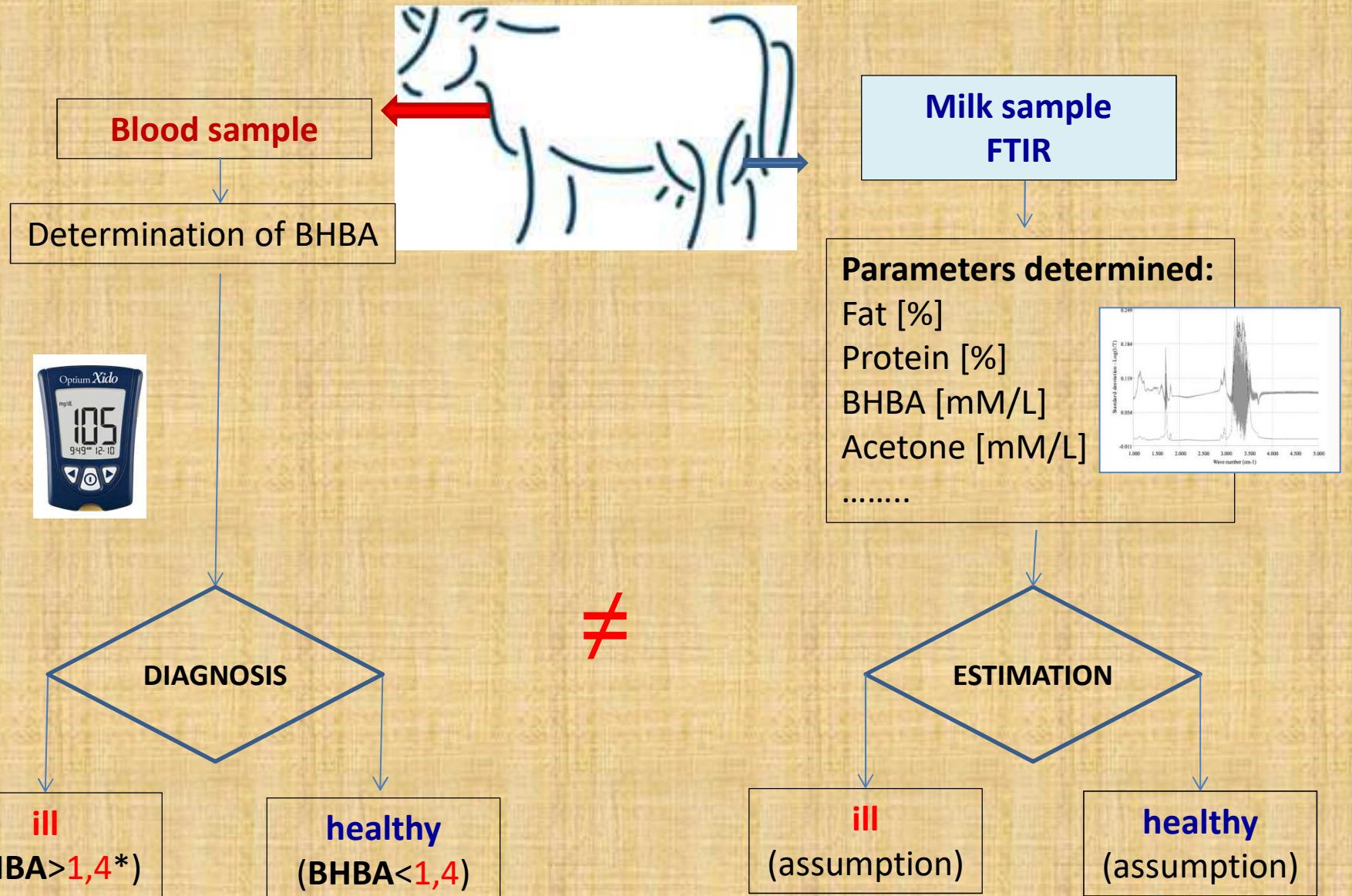


Total cost per case of ketosis ($\geq 1.2 \text{ mmol/L}$):

- for primiparous \$375
- for multiparous \$256
- average \$289

McArt et al., 2015

Diagnosis or Estimation of Ketosis



*mM/L

Important facts.....



„X“ – 4 laboratories with 9 CombiFoss FT+ using FTIR
(Foss Analytical A/S, Hillerød, Denmark)

Milk acetone (ACE) and β -hydroxybutyrate (BHBA)

Polish model

- Logistic regression model, developed on 1091 cows, including 153 ketotic ($>1.4 \text{ mmol/L}$) (Kowalski et al., 2015)
- Parameters included in the model:

variable	regression coefficient	P-value
Intercept	-3.6336	<0.001
ACE [mmol/L]	6.3874	<0.001
BHBA [mmol/L]	10.9514	<0.001
F/P ratio	0.4507	0.035

- Index „K! ” she was **probably ill** on a test-day
- Sensitivity 71%, Specificity 90%

Polish model

- Monthly milk recording (A4, AT4 and A8 methods)
- Identification of **probably** risky cows on a test-day – within 5-60 DIM
- Identification of **probably** risky herds (PFSK – probable frequency of ketosis in the herd)
- Monitoring was started on 1st March 2013
- It covers all cows and herds recorded



- The first nationwide system covering monthly about 770 000 cows
- Farmers are informed within 3-4 days (on line)
- No additional charge for ketosis monitoring

Prevalence of ketosis in Poland

- Based on database of

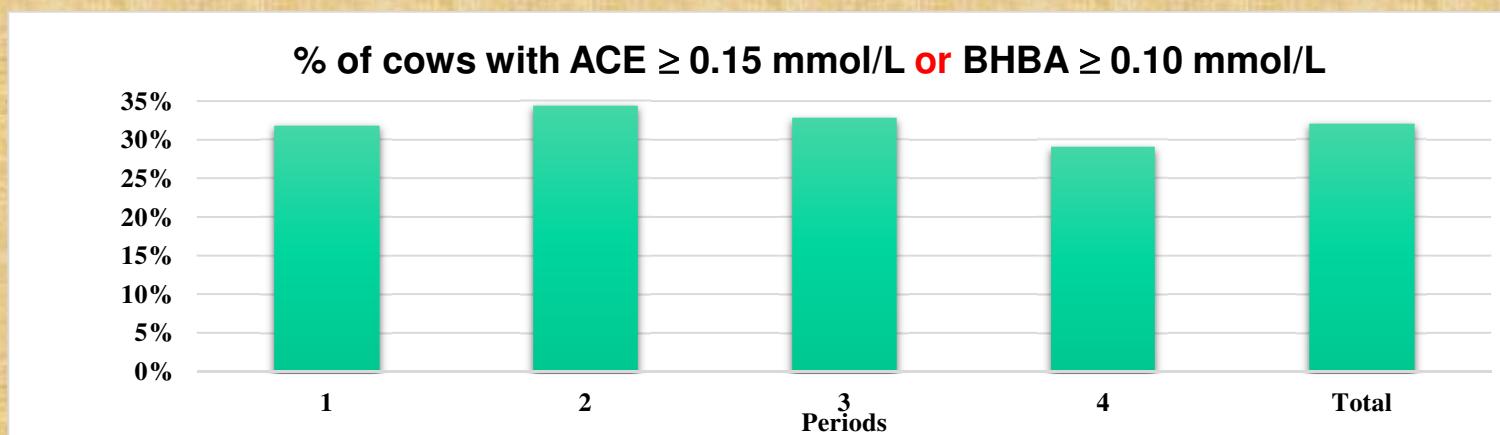


- Period 1. 01-04-2013 ÷ 31-03-2014
- Period 2. 01-04-2014 ÷ 31-03-2015
- Period 3. 01-04-2015 ÷ 31-03-2016
- Period 4. 01-04-2016 ÷ 31-03-2017
- On a cow level
- **Ketotic cow**
 - K !
 - Milk ACE ≥ 0.15 mmol/L
 - Milk BHBA ≥ 0.10 mmol/L
 - Milk ACE ≥ 0.15 mmol/L or BHBA ≥ 0.10 mmol/L

Prevalence of ketosis in Poland

	Period				Total
	1	2	3	4	
N cows ¹	884 423	932 782	1 187 030	1 204 938	4 209 173
Ketotic cows, %					
K !	9.4	10.0	9.8	8.4	9.5
ACE \geq 0.15 mmol/L	14.7	21.9	20.8	18.7	19.0
BHBA \geq 0.10 mmol/L	30.5	31.7	30.1	26.3	29.7
ACE \geq 0.15 mmol/L or BHBA \geq 0.10 mM/L	31,8	34,4	32,8	29,1	32,0

¹ Milk samples



Prevalence of ketosis in Poland



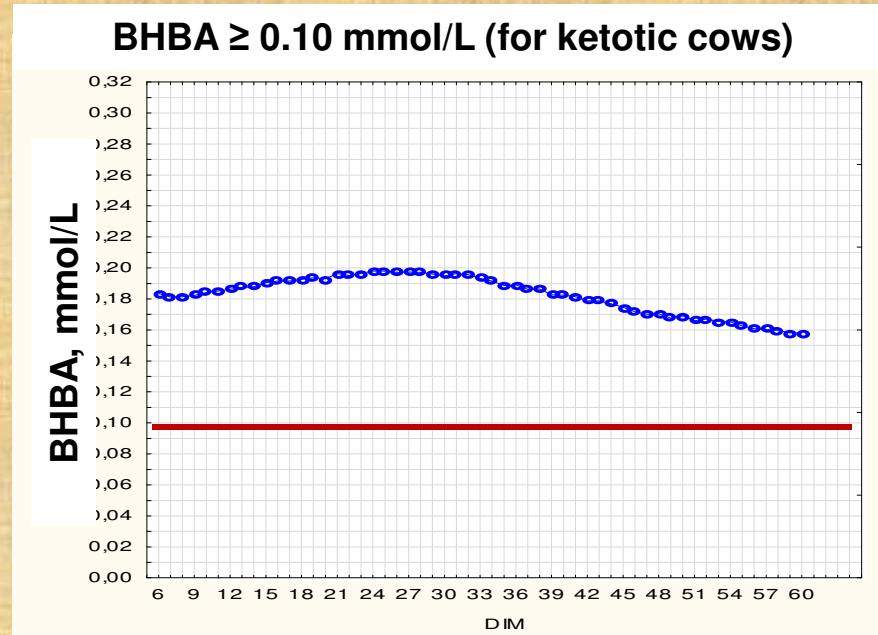
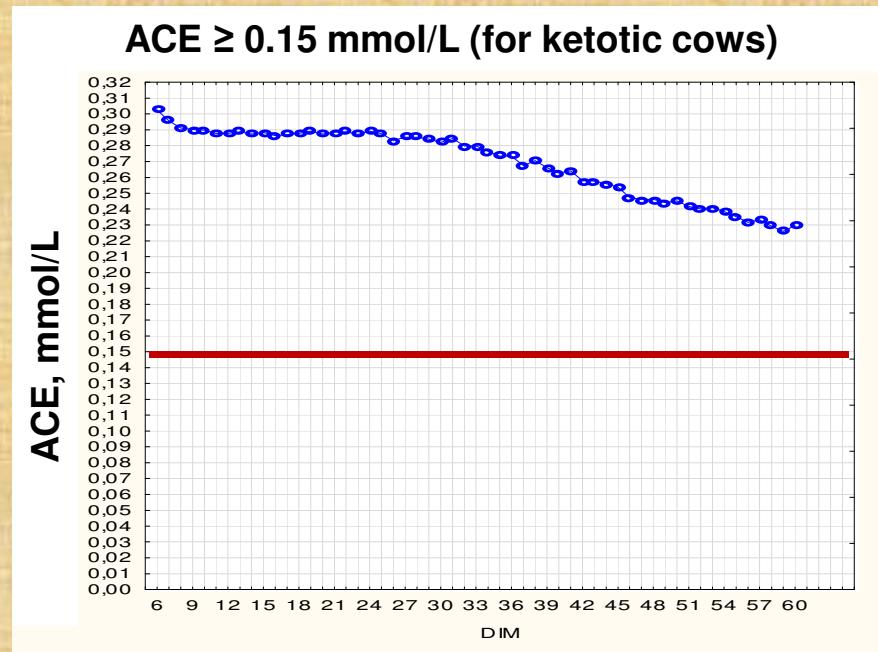
- Database period 1 and 2 (from 1-04-2013 to 31-03-2015)
- 1 817 205 records
 - 553 592 records for 6-21 DIM type 2
 - 1 263 613 records for 22-60 DIM type 1



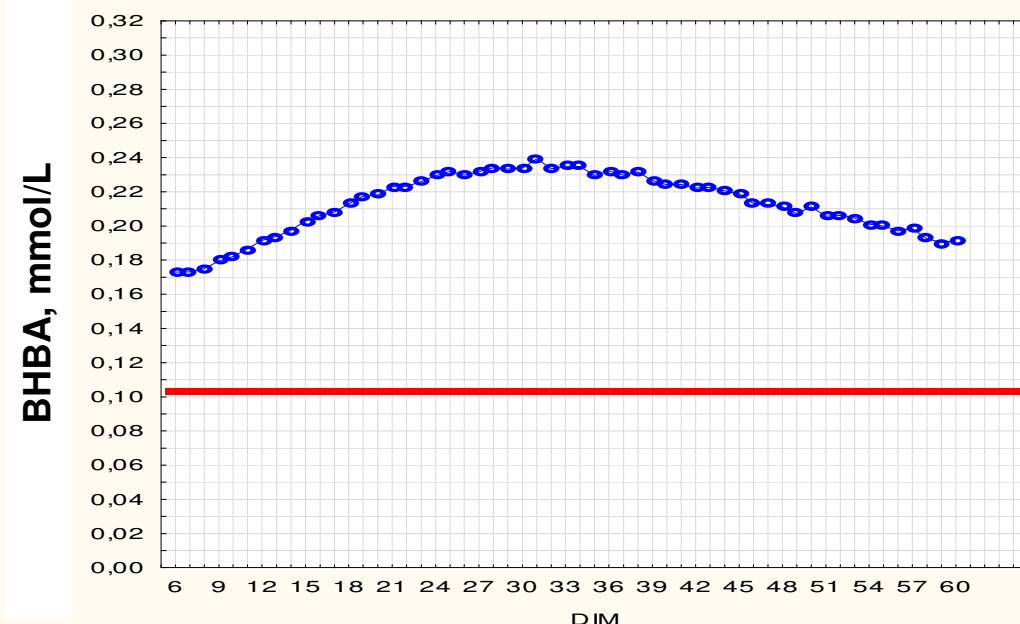
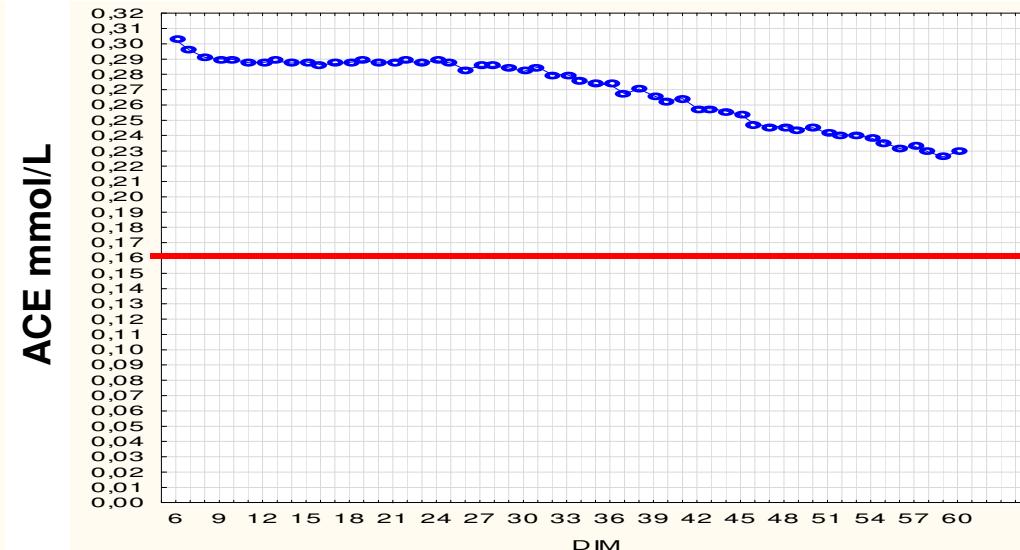
Oetzel, 2007

Milk analyses

- 4 labs, 9 FTIR MilkoScan FT6000
- ketotic cows, if milk...
 - ACE $\geq 0.15 \text{ mmol/L}$
 - BHBA $\geq 0.10 \text{ mmol/L}$
 - ACE $\geq 0.15 \text{ mmol/L}$ or BHBA $\geq 0.10 \text{ mmol/L}$



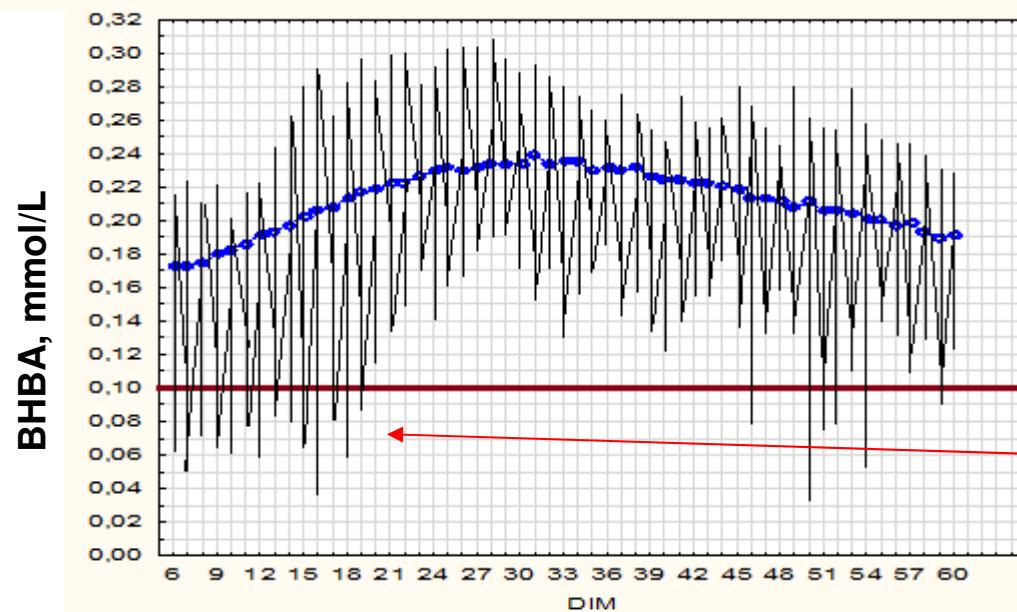
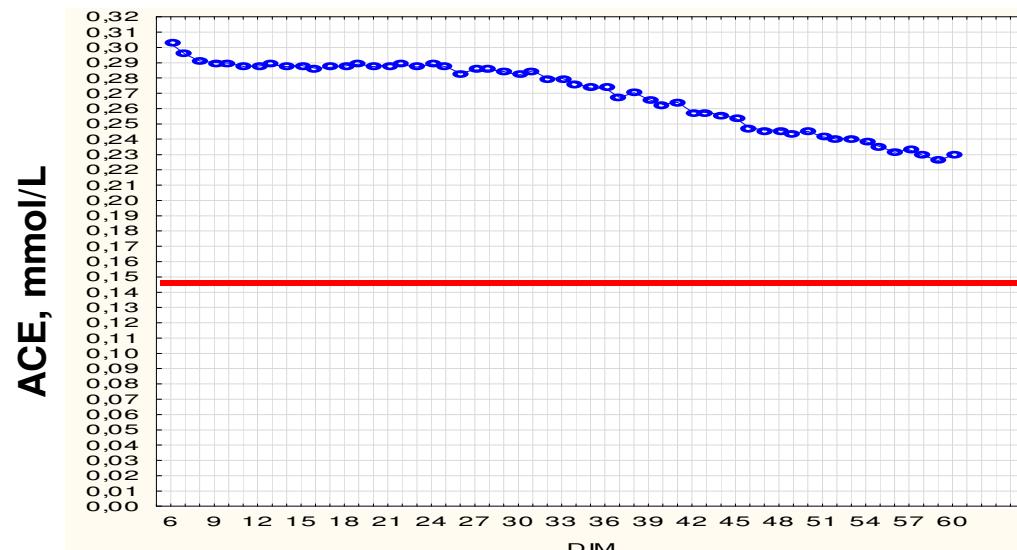
ACE ≥ 0.15 mmol/L (for ketotic cows)



Mean milk BHBA
(mmol/L) in cows
considered ketotic
based on milk ACE



ACE ≥ 0.15 mmol/L



How many cows ?

Prevalence of ketosis in Poland

N of healthy and ketotic cows depending of milk ACE and/or BHBA

	DIM		
	6 - 60	6 - 21	22 - 60
N milk samples	1 817 205	553 592	1 263 613
N cows with ACE \geq 0.15 mmol/L or BHBA \geq 0.10 mmol/L ¹	602 603	238 177	364 426
% total	33.16 %	40.02 %	28.84 %
N cows with ACE \geq 0.15 mmol/L and BHBA < 0.10 mmol/L	40 110	24 153	15 957
% total	2.21 %	4.36 %	1.26 %
% ketotic	6.66 %	10.14 %	4.38 %

¹ considered as ketotic



What have we learnt about ketosis in Poland ?

RESULTS of monitoring of ketosis in Poland – 2 years

Period: from 2013-04-01 to 2015-03-31

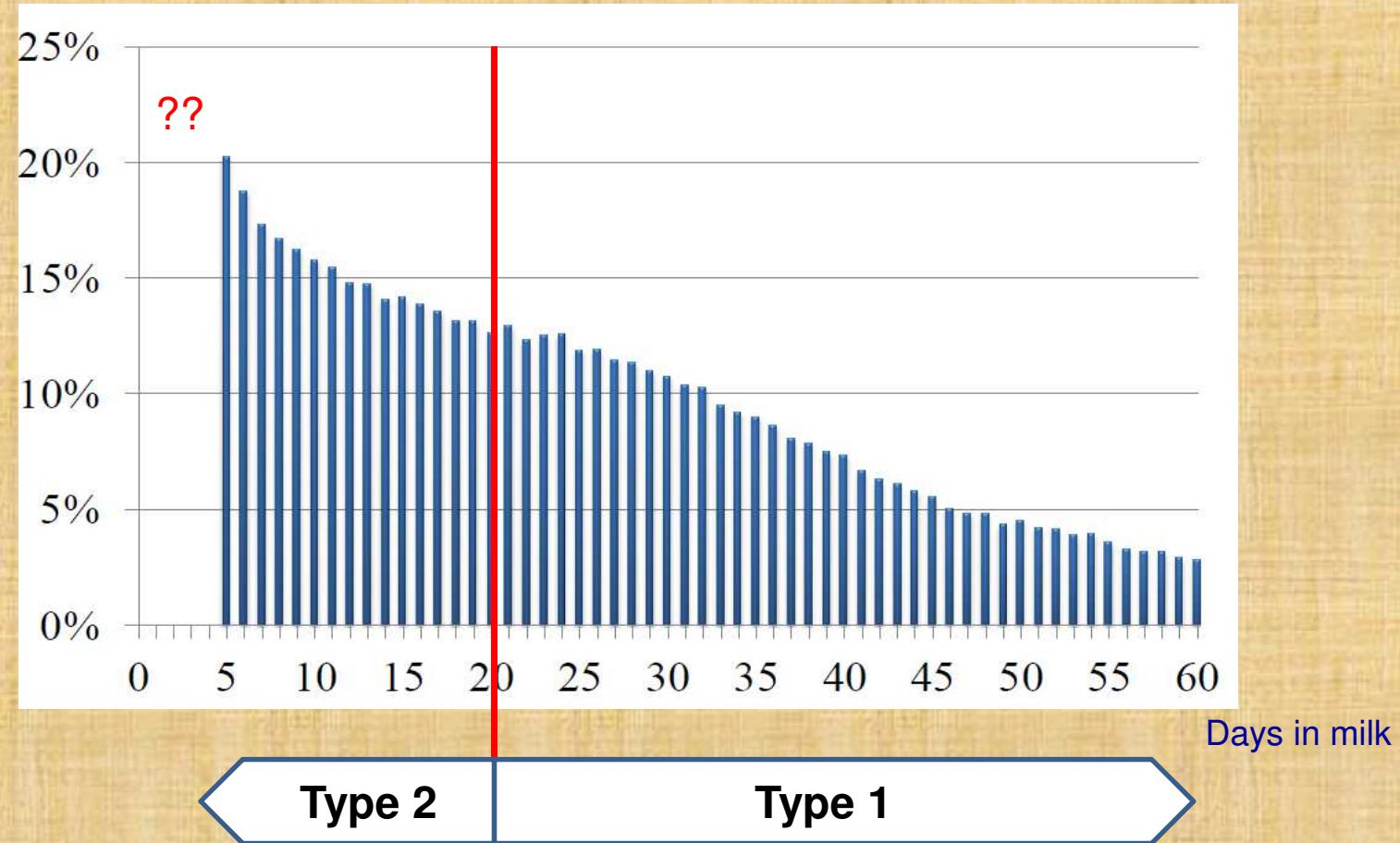
Milk samples: 1 846 876

Based on K !

What have we learnt?

Types of ketosis depending on days in milk (Oetzel, 2007)

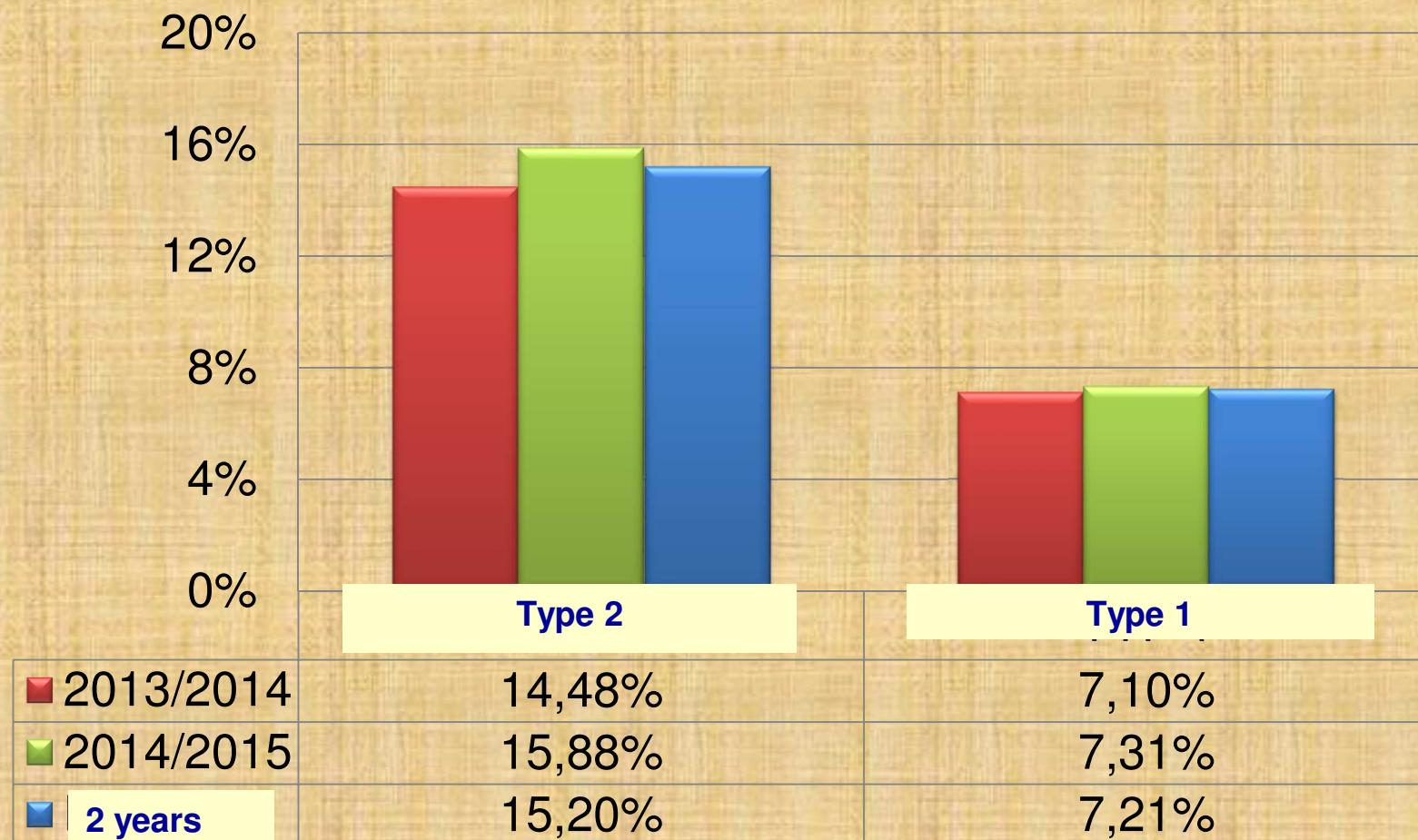
KI cows



What have we learnt?

Cows at risk of ketosis (K !) of type 1 or type 2, %

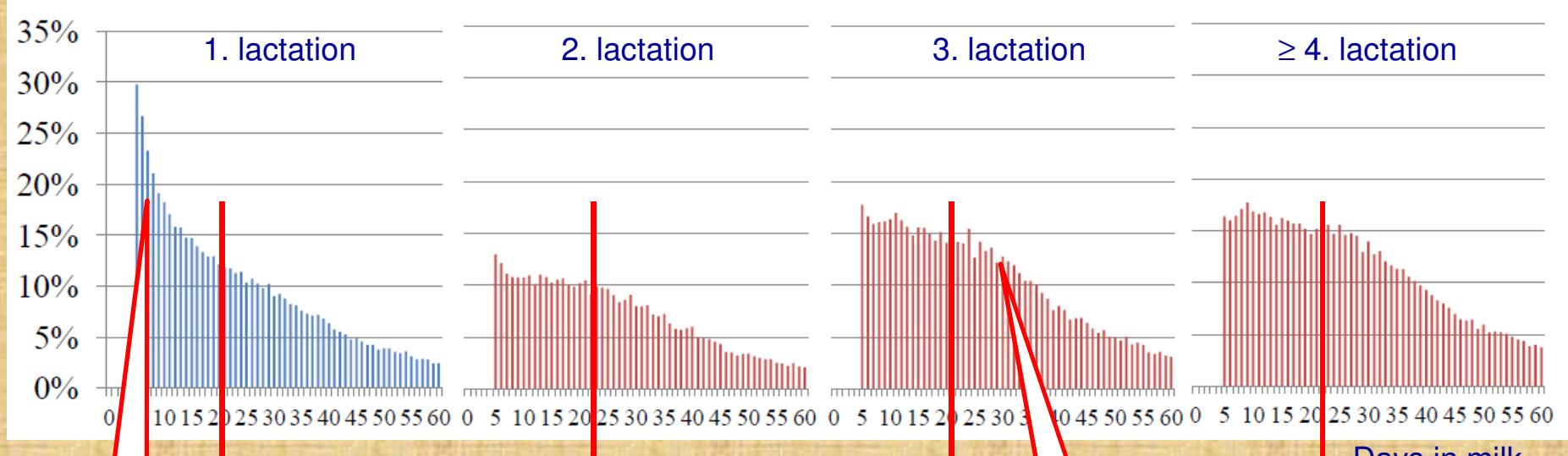
K! cows



What have we learnt?

Cows at risk of ketosis (K!) depending on parity, %

K! cows



Overfattening !

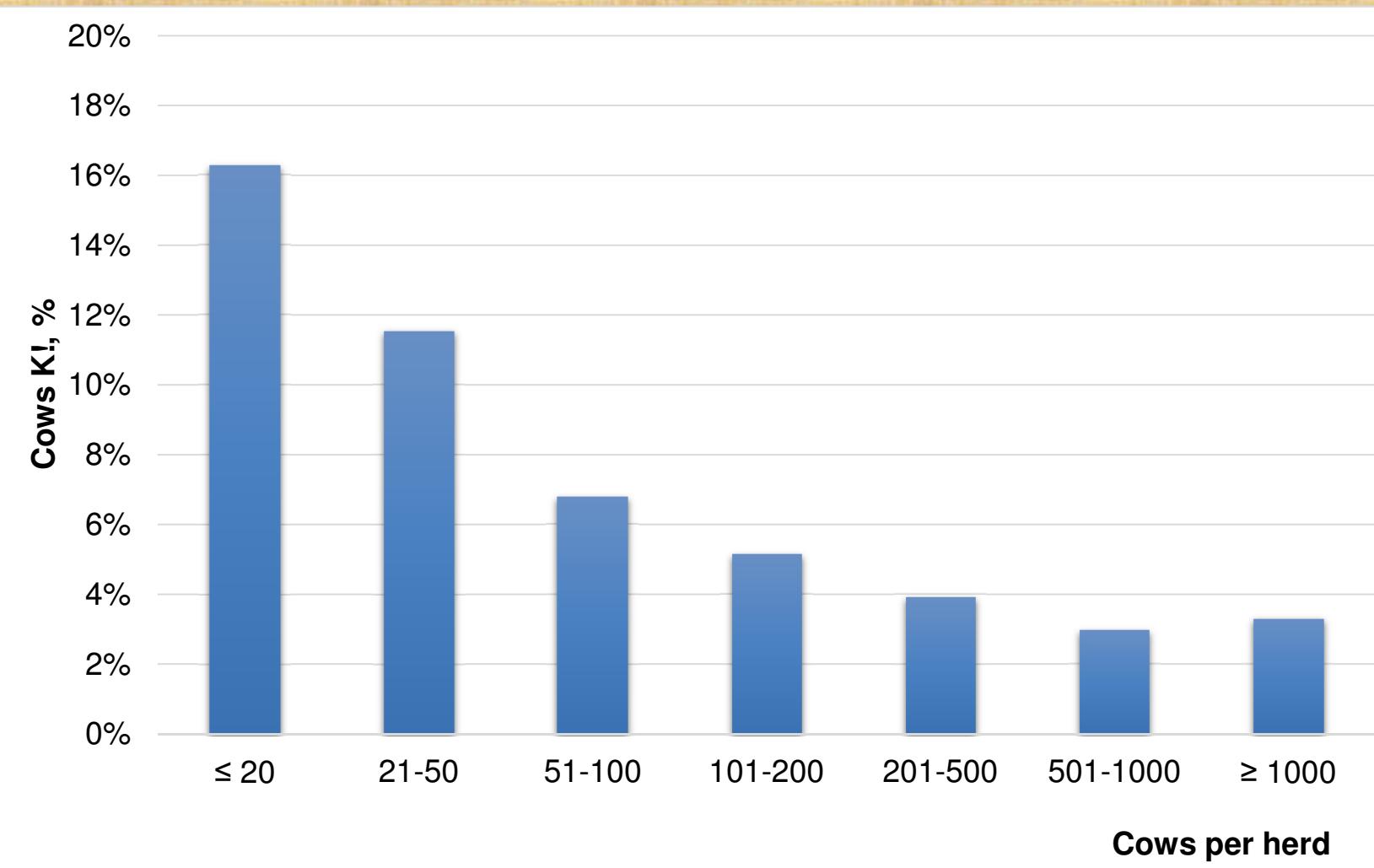


A lack of „fuel”



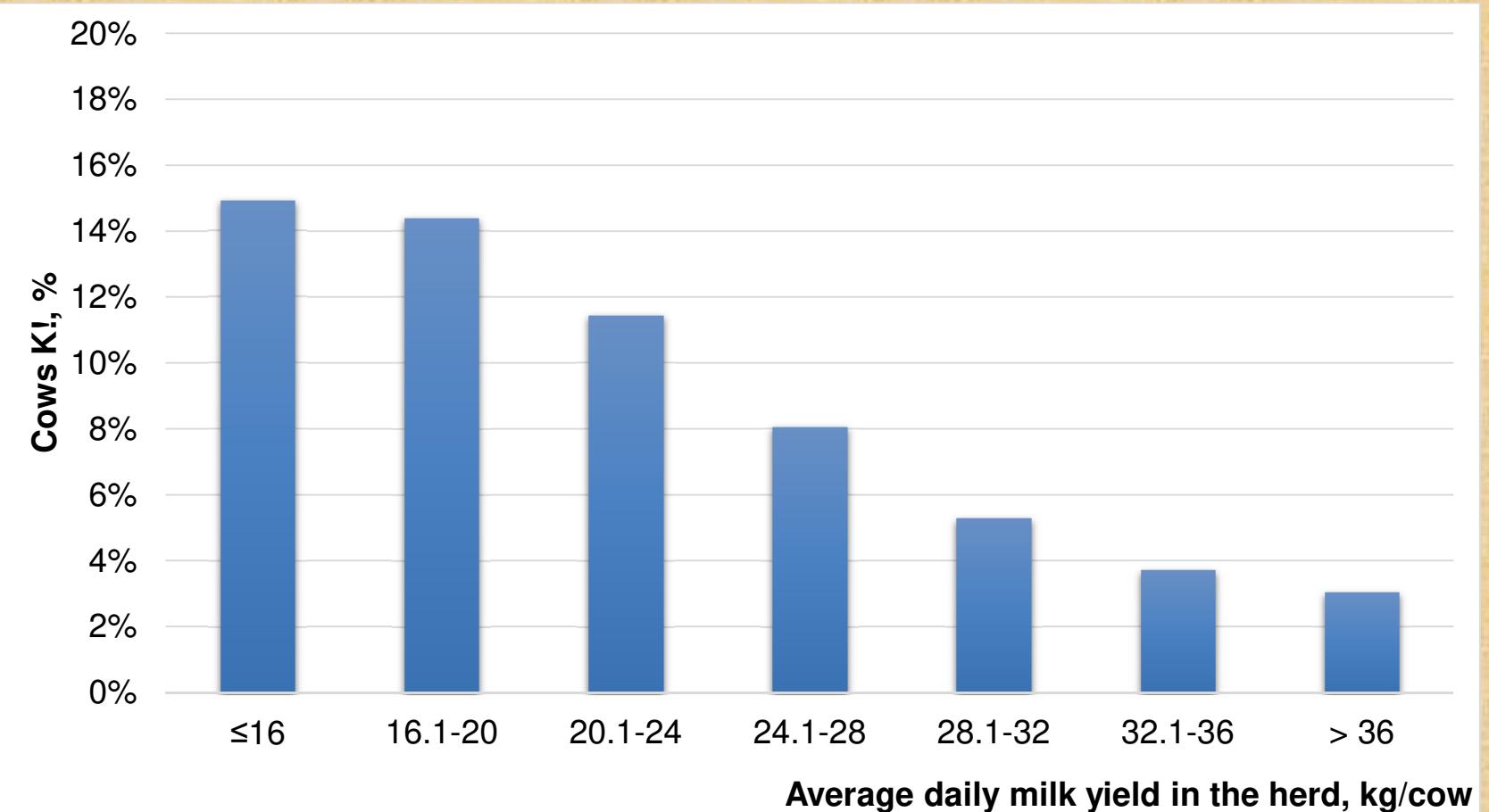
What have we learnt?

Cows at risk of ketosis (K !) depending on herd size (4-year data)



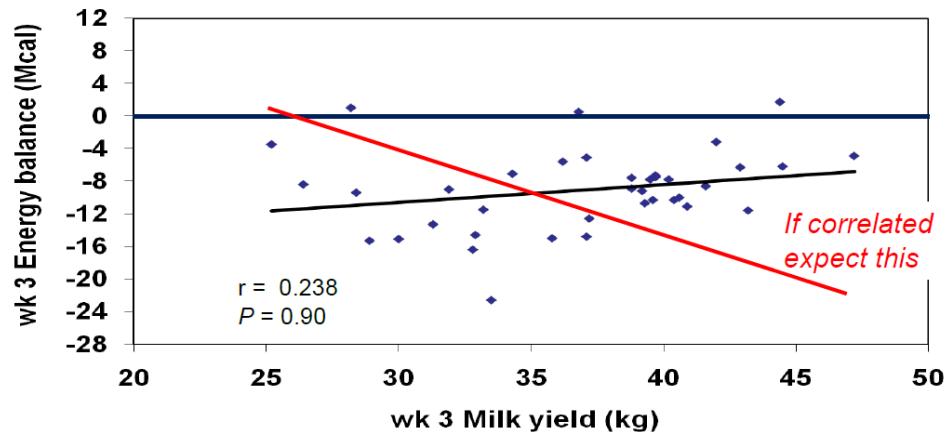
What have we learnt?

Cows at risk of ketosis (K !) depending on average milk yield of
the herd on test-day (4-year data)

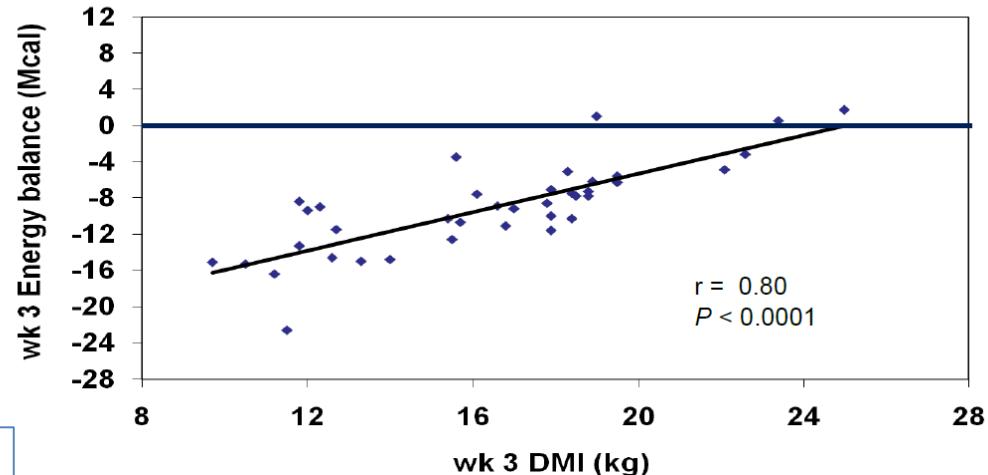


What have we learnt?

Post-calving energy balance is not correlated with milk yield



Post-calving energy balance is highly correlated with DMI



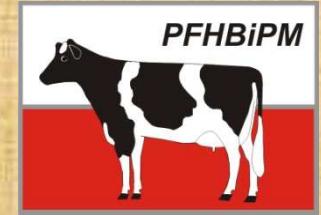
Drackley, 2006

Risk factors for ketosis ?

- Well known, universal
 - Excessive BCS ↑
 - Low DMI in close up and transition period *postpartum* ↑
 - Increased parity ↑
 - Dry period length ↑
 - Poor transition feed management ↑
 - Poor welfare standards ↑
 - Season of calving
- Specific for the region, area, breed etc.

Van Holder et al., 2015

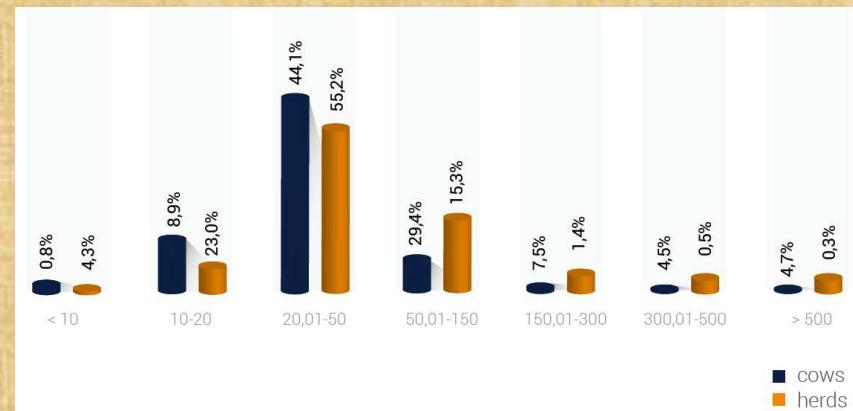
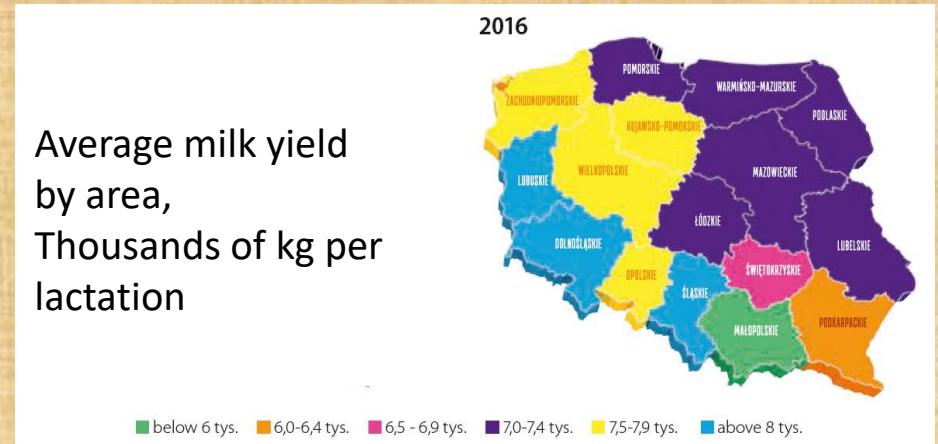
Risk factors for ketosis in Poland ?



Important facts.....

Year	Average number of cows	Milk
2016	768 749	7 865

Average milk yield by area,
Thousands of kg per lactation



Risk factors for ketosis in Poland ?

RESULTS of monitoring of ketosis in Poland – 4 months

Period: from 01-05-2014 to 31-08-2014

Milk samples: 211 939

Dataset 1

Questionare:

- 10 questions
- 15859 answers

Dataset 2

Risk factors for ketosis in Poland ?



Variables evaluated for individual cows

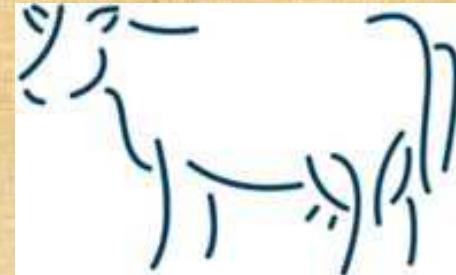
	Type of variable	Value
Dataset 1		
Parity	Categorical	1, 2, 3, 4, 5, 6 and ≥ 7
Days in milk	Continuous	6-13, 14-21, 22-29, 30-37, 38-45, 46-53, 54-60
Lactation length, days	Continuous	Previous lactation length in days
Herd size (N cows)	Continuous	≤ 20 , 21-50, 51-100, 101-200, 201-500, 501-1000 , > 1000
Daily herd milk yield, kg/d	Continuous	≤ 16 , 16.1-20, 20.1-24, 24.1-28, 28.1-32, 32.1-36, and ≥ 36.1
Age of First Calving primiparous	Continuous	Days
Season	Categorical	May, June, July, August
Dataset 2		
Housing system	Categorical	Tie-stalls, Free-stalls or Deep-litter free-stalls
Grazing	Categorical	Yes or No
Feeding system	Categorical	Traditional, TMR, PMR
Cow grouping	Categorical	Yes or No
Dry cow groups	Categorical	0, 1 or ≥ 2
Checking BCS	Categorical	Yes or No
Farmers education	Categorical	Primary, basic vocational education, secondary, high
Agricultural education	Categorical	Yes or No
Feed chemical analysis	Categorical	Yes or No
Farm modernization, years/ago	Categorical	<5, 5-10, 10-15, 15-20 and >20

Risk factors for ketosis in Poland ?

	Type of variable
Dataset 1	
Parity	Categorical
Days in milk	Continuous
Lactation length, days	Continuous
Herd size (N cows)	Continuous
Daily herd milk yield, kg/d	Continuous
Age of First Calving primiparous	Continuous
Season	Categorical
Dataset 2	
Housing system	Categorical
Grazing	Categorical
Feeding system	Categorical
Cow grouping	Categorical
Dry cow groups	Categorical
Checking BCS	Categorical
Farmers education	Categorical
Agricultural education	Categorical
Feed chemical analysis	Categorical
Farm modernization, years/ago	Categorical

Healthy (NK) or Ketotic (K)

ACE ≥ 0.15 mmol/L or BHBA ≥ 0.10 mmol/L



- Generalized logit mixed models of factors associated with dependent variable Y (NK or K)
- Multivariable multinomial logistic regression compared the odds of (OR) a cow being NK or K for various risk factors
- Variables were tested for inclusion in the model by stepwise selection procedure (P-value for retention P < 0.05)
- Model 1. for all cows
- Model 2. for primiparous cows
- Model 3. for multiparous cows

Risk factors for ketosis in Poland ?



Distribution of ketosis (based on 211 939 milk samples)

	All milk samples, %	No ketosis	Ketosis
All cows (milk samples)		63.51%	36.49%
Primiparous	32.88	65.13%	34.87%
Multiparous	67.12	62.72%	37.28%
Days in milk			
6-13	16.69	49.72%	50.28%
14-21	15.08	56.48%	43.52%
22-29	13.95	60.75%	39.25%
30-37	13.86	64.50%	35.50%
38-45	15.24	69.35%	30.65%
46-53	13.65	72.87%	27.13%
54-60	11.52	76.06%	23.94%
Previous lactation days, (multiparous)		396 days	425 days
Age of first calving (primiparous)		780 days	787 days

Risk factors for ketosis in Poland ?

Distribution of ketosis (based on 211 939 milk samples)

	All milk samples, %	No ketosis	Ketosis
Herd size			
≤ 20	12.65	53.60%	46.40%
21-50	47.05	60.30%	39.70%
51-100	18.86	66.69%	33.31%
101-200	8.82	71.60%	28.40%
201-500	7.65	74.40%	25.60%
501-1000	3.65	76.09%	23.91%
>1001	1.33	75.65%	24.35%
Herd milk yield, kg/d			
≤16	4.21	52.97%	47.03%
16.1-20	15.02	55.52%	44.48%
20.1-24	28.00	58.72%	41.28%
24.1-28	27.35	65.52%	34.48%
28.1-32	16.70	70.79%	29.21%
32.1-36	7.07	76.41%	23.59%
> 36.1	1.66	82.22%	17.78%

Risk factors for ketosis in Poland ?



Distribution of ketosis

(based on 211 939 milk samples and data from 15 859 herds)

	Herds, %	All milk samples, %	No ketosis	Ketosis
Barn type				
Tie-stalls	83.32	63.78	59.70%	40.30%
Free-stalls	11.66	27.76	70.28%	29.72%
Deep-litter free-stalls	4.68	7.68	69.58%	30.42%
Grazing				
Yes	43.57	31.87	65.40%	34.60%
No	55.91	67.69	62.62%	37.38%
Feeding system				
Traditional	67.66	46.95	58.89%	41.11%
TMR	28.17	46.74	67.50%	32.50%
PMR	4.17	6.14	68.67%	31.33%
Cow grouping				
Yes	29.70	43.82	67.76%	32.24%
No	69.87	55.75	60.19%	39.81%

Risk factors for ketosis in Poland ?



Distribution of ketosis

(based on 211 939 milk samples and data from 15 859 herds)

	Herds, %	All milk samples, %	No ketosis	Ketosis
Dry cow groups				
0	39.40	26.61	56.60%	43.40%
1	51.32	55.30	64.49%	35.51%
≥ 2	9.11	17.80	70.74%	29.26%
Checking BCS				
Yes	9.70	17.81	67.62%	32.38%
No	89.45	81.19	62.64%	37.36%
Farmer education				
Primary	4.85	3.72	65.55%	34.45%
Secondary	41.36	34.10	60.65%	39.35%
Post-secondary	42.47	40.50	62.70%	37.30%
Basic vocational education	11.06	21.30	69.35%	30.65%

Risk factors for ketosis in Poland ?



Distribution of ketosis

(based on 211 939 milk samples and data from 15 859 herds)

	Herds, %	All milk samples, %	No ketosis	Ketosis
Agricultural education				
Yes	76.34	81.16	63.55%	36.45%
No	23.23	18.34	63.47%	36.53%
Feed chemical analysis				
Yes	36.34	54.68	66.78%	33.22%
No	63.40	44.63	59.48%	40.52%
Farm modernization, years/ago				
< 5	21.79	23.87	64.84%	35.16%
5-10	31.66	35.84	64.34%	35.66%
10.1-15	19.49	21.06	64.36%	35.64%
15.1-20	9.53	7.72	59.91%	40.09%
> 20.1	17.19	11.14	58.45%	41.55%

Risk factors for ketosis in Poland ?

Model 1. all cows – „production” variables

Risk factor	Value	Estimate	SE	OR	95% Confidence limits		P-value
					Lower	Higher	
Intercept	Continuous	0.29	0.04				<.0001
Parity	Parity 2 vs. 1	-0.18	0.01	0.84	0.82	0.86	<.0001
	Parity 3 vs. 1	0.16	0.01	1.17	1.14	1.20	<.0001
	Parity 4 vs. 1	0.22	0.02	1.25	1.21	1.29	<.0001
	Parity 5 vs. 1	0.21	0.02	1.23	1.18	1.28	<.0001
	Parity 6 vs. 1	0.16	0.03	1.17	1.12	1.23	<.0001
	Parity 7 vs. 1	0.05	0.02	1.06	1.01	1.11	0.0277
Days in milk	14-21 vs. 6-13	-0.26	0.02	0.77	0.75	0.79	<.0001
	22-29 vs. 6-13	-0.43	0.02	0.65	0.63	0.67	<.0001
	30-37 vs. 6-13	-0.62	0.02	0.54	0.52	0.56	<.0001
	38-45 vs. 6-13	-0.84	0.02	0.43	0.42	0.44	<.0001
	46-53 vs. 6-13	-1.00	0.02	0.37	0.36	0.38	<.0001
	54-60 vs. 6-13	-1.17	0.02	0.31	0.30	0.32	<.0001
Season	June vs. May	0.02	0.01	1.02	1.00	1.05	0.0729
	July vs. May	0.24	0.01	1.27	1.24	1.30	<.0001
	August vs. May	0.05	0.01	1.05	1.02	1.08	0.0004
Herd size	21-50 vs. ≤20	-0.22	0.02	0.80	0.78	0.83	<.0001
	51-100 vs. ≤20	-0.42	0.02	0.66	0.63	0.68	<.0001
	101-200 vs. ≤20	-0.62	0.03	0.54	0.51	0.57	<.0001
	201-500 vs. ≤20	-0.60	0.03	0.55	0.52	0.58	<.0001
	501-1000 vs. ≤20	-0.56	0.04	0.57	0.53	0.61	<.0001
	>1000 vs. ≤20	-0.49	0.06	0.62	0.55	0.70	<.0001
Average daily herd milk yield	16.1-20 vs. ≤16	-0.09	0.02	0.92	0.87	0.96	0.0004
	20.1-24 vs. ≤16	-0.20	0.02	0.82	0.79	0.86	<.0001
	24.1-28 vs. ≤16	-0.46	0.02	0.63	0.60	0.67	<.0001
	28.1-32 vs. ≤16	-0.62	0.03	0.54	0.51	0.57	<.0001
	32.1-36 vs. ≤16	-0.87	0.03	0.42	0.39	0.45	<.0001
	≥ 36.1 vs. ≤16	-1.25	0.05	0.29	0.26	0.32	<.0001

Risk factors for ketosis in Poland ?

Model 2. primiparous cows – „production” variables

Risk factor	Value	Estimate	SE	OR	95% Confidence limits		P-value
					Lower	Higher	
Intercept	Continuous	1.02	0.10				<.0001
Day of first calving	Days	0.01	0.00		1.00	1.01	0.0103
Days in milk	14-21 vs. 6-13	-0.45	0.03	0.64	0.60	0.68	<.0001
	22-29 vs. 6-13	-0.74	0.03	0.48	0.45	0.51	<.0001
	30-37 vs. 6-13	-0.91	0.03	0.40	0.38	0.43	<.0001
	38-45 vs. 6-13	-1.14	0.03	0.32	0.30	0.34	<.0001
	46-53 vs. 6-13	-1.27	0.03	0.28	0.26	0.30	<.0001
	54-60 vs. 6-13	-1.50	0.03	0.22	0.21	0.24	<.0001
Season	June vs. May	0.04	0.02	1.04	0.99	1.08	0.1173
	July vs. May	0.23	0.02	1.26	1.20	1.32	<.0001
	August vs. May	0.01	0.03	1.01	0.96	1.07	0.6654
Herd size	21-50 vs. ≤20	-0.42	0.03	0.66	0.62	0.70	<.0001
	51-100 vs. ≤20	-0.70	0.04	0.50	0.46	0.54	<.0001
	101-200 vs. ≤20	-0.88	0.05	0.42	0.38	0.46	<.0001
	201-500 vs. ≤20	-0.89	0.05	0.41	0.37	0.46	<.0001
	501-1000 vs. ≤20	-0.78	0.07	0.46	0.40	0.52	<.0001
	>1000 vs. ≤20	-0.81	0.11	0.44	0.36	0.56	<.0001
Average daily herd milk yield	16.1-20 vs. ≤16	-0.09	0.05	0.92	0.83	1.01	0.0862
	20.1-24 vs. ≤16	-0.25	0.05	0.78	0.71	0.86	<.0001
	24.1-28 vs. ≤16	-0.57	0.05	0.56	0.51	0.62	<.0001
	28.1-32 vs. ≤16	-0.78	0.05	0.46	0.42	0.51	<.0001
	32.1-36 vs. ≤16	-1.11	0.06	0.33	0.29	0.37	<.0001
	≥ 36.1 vs. ≤16	-1.58	0.10	0.21	0.17	0.25	<.0001

Days:
NK 780; K 787



Risk factors for ketosis in Poland ?

Model 3. multiparous cows – „production” variables

Risk factor	Value	Estimate	SE	OR	95% Confidence limits		P-value
					Lower	Higher	
Intercept	Continuous	-1.52	0.06				<.0001
Parity	Parity 3 vs. 2	0.37	0.02	1.44	1.40	1.49	<.0001
	Parity 4 vs. 2	0.45	0.02	1.57	1.52	1.63	<.0001
	Parity 5 vs. 2	0.44	0.02	1.56	1.49	1.62	<.0001
	Parity 6 vs. 2	0.41	0.03	1.51	1.43	1.59	<.0001
	Parity 7 vs. 2	0.33	0.03	1.39	1.32	1.46	<.0001
Lactation length	Days	0.00	0.00	1.00	1.00	1.00	<.0001
Days in milk	14-21 vs. 6-13	-0.19	0.02	0.83	0.80	0.86	<.0001
	22-29 vs. 6-13	-0.30	0.02	0.74	0.71	0.77	<.0001
	30-37 vs. 6-13	-0.50	0.02	0.61	0.58	0.63	<.0001
	38-45 vs. 6-13	-0.72	0.02	0.49	0.47	0.51	<.0001
	46-53 vs. 6-13	-0.90	0.02	0.41	0.39	0.43	<.0001
	54-60 vs. 6-13	-1.06	0.02	0.35	0.33	0.36	<.0001
Season	June vs. May	0.01	0.02	1.01	0.98	1.05	0.4097
	July vs. May	0.23	0.02	1.25	1.21	1.29	<.0001
	August vs. May	0.05	0.02	1.05	1.02	1.09	0.0043
Herd size	21-50 vs. ≤20	-0.17	0.02	0.85	0.82	0.88	<.0001
	51-100 vs. ≤20	-0.35	0.03	0.70	0.67	0.74	<.0001
	101-200 vs. ≤20	-0.55	0.03	0.58	0.54	0.62	<.0001
	201-500 vs. ≤20	-0.47	0.04	0.63	0.58	0.68	<.0001
	501-1000 vs. ≤20	-0.48	0.05	0.62	0.56	0.68	<.0001
	>1000 vs. ≤20	-0.31	0.07	0.73	0.63	0.85	<.0001
Average daily herd milk yield	16.1-20 vs. ≤16	-0.06	0.03	0.95	0.89	1.01	0.0772
	20.1-24 vs. ≤16	-0.14	0.03	0.87	0.82	0.92	<.0001
	24.1-28 vs. ≤16	-0.38	0.03	0.68	0.64	0.73	<.0001
	28.1-32 vs. ≤16	-0.52	0.03	0.59	0.56	0.63	<.0001
	32.1-36 vs. ≤16	-0.72	0.04	0.48	0.45	0.53	<.0001
	≥36.1 vs. ≤16	-1.08	0.07	0.34	0.30	0.38	<.0001

Days:
NK 396; K 425



Risk factors for ketosis in Poland ?

Model 1. All cows – „herd” variables

Risk factor	Value	Estimate	SE	OR	95% Confidence limits		P-value
					Lower	Higher	
Housing system	Free-stalls vs. Tie-stalls	-0.11	0.02	0.90	0.87	0.92	<.0001
	Deep-litter FS vs. Tie-stalls	-0.15	0.02	0.86	0.83	0.90	<.0001
Grazing	No vs. Yes	0.49	0.01	1.64	1.60	1.67	<.0001
	TMR vs. Traditional	0.00	0.01	1.00	0.97	1.02	0.7094
Feeding system	PMR vs. Traditional	-0.15	0.02	0.86	0.83	0.90	<.0001
	No vs. Yes	0.04	0.01	1.04	1.02	1.07	0.0005
Cow grouping	One vs. No	-0.15	0.01	0.86	0.84	0.88	<.0001
	Two or more vs. No	-0.14	0.02	0.87	0.84	0.90	<.0001
Dry cow grouping	No vs. Yes	-0.08	0.01	0.93	0.90	0.95	<.0001
	Checking BCS	0.20	0.03	1.22	1.16	1.29	<.0001
Farmer education	Basic vocational education vs. Primary education	0.19	0.03	1.21	1.15	1.27	<.0001
	Secondary education vs. Primary education	0.21	0.03	1.23	1.16	1.30	<.0001
	Higher education vs. Primary education	-0.10	0.01	0.91	0.88	0.93	<.0001
Agricultural education	No vs. Yes	-0.03	0.01	0.97	0.95	0.99	0.0081
	Feed chemical composition analysis	5-10 vs. <5 years ago	-0.02	0.01	0.98	0.95	1.00
Modernization of the farm	10-15 vs. <5 years ago	-0.06	0.01	0.95	0.92	0.97	<.0001
	15-20 vs. <5 years ago	0.01	0.02	1.01	0.97	1.05	0.6742
	>20 vs. <5 years ago	0.07	0.02	1.08	1.04	1.12	<.0001

Conclusions

- Monitoring of cows for ketosis, based on test-day milk sample analysis by FTIR, allows for better control of the dairy cows health
- About 10% of ketotic cows within 6-21 DIM have elevated milk ACE, but not milk BHBA. They can not be diagnosed as ketotic when the hand-held glucometer is used
- At least in Poland, ketosis is not a disease of high-yielding cows. In contrast, it is a disease of cows kept in poor environmental conditions and poorly fed
- Among risk factors for ketosis in Poland the most important are parity, DIM, herd size, average herd daily milk yield, housing system, cow grouping

Thank you for your attention !

