Faculty of Agricultural and Nutritional Science

Christian-Albrechts-University Kiel
Institute of Animal Breeding and Husbandry

# Indirect online detection of udder health with an automated California Mastitis Test

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64th Annual Meeting of the EAAP, Nantes, France
26th August to 30th August 2013
Session 44


# Introduction

- In the animal welfare management of a dairy farm,
  udder health is essential for economical successful leadership

- Mastitis control is possible with several commercial available sensor systems *(Brandt et al., 2010; Hogeveen et al., 2010; Rutten et al., 2013)*

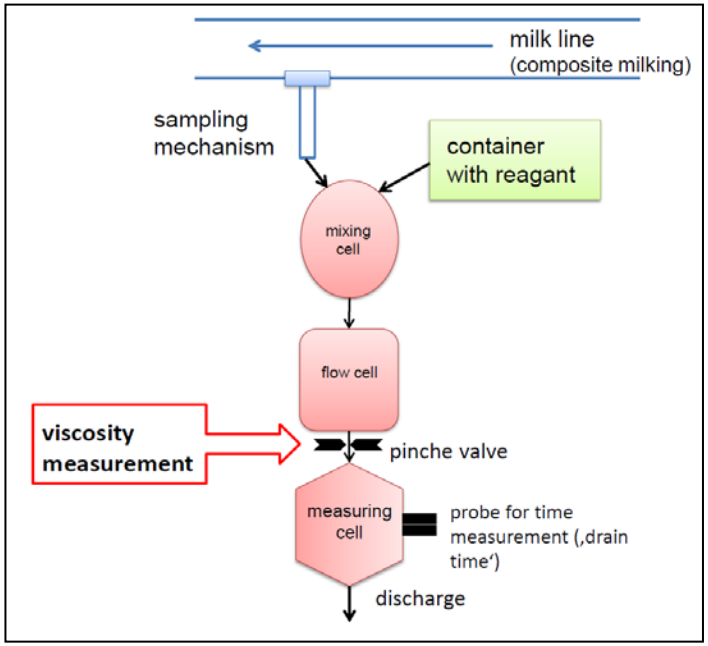
- Different udder health parameters are varying informative

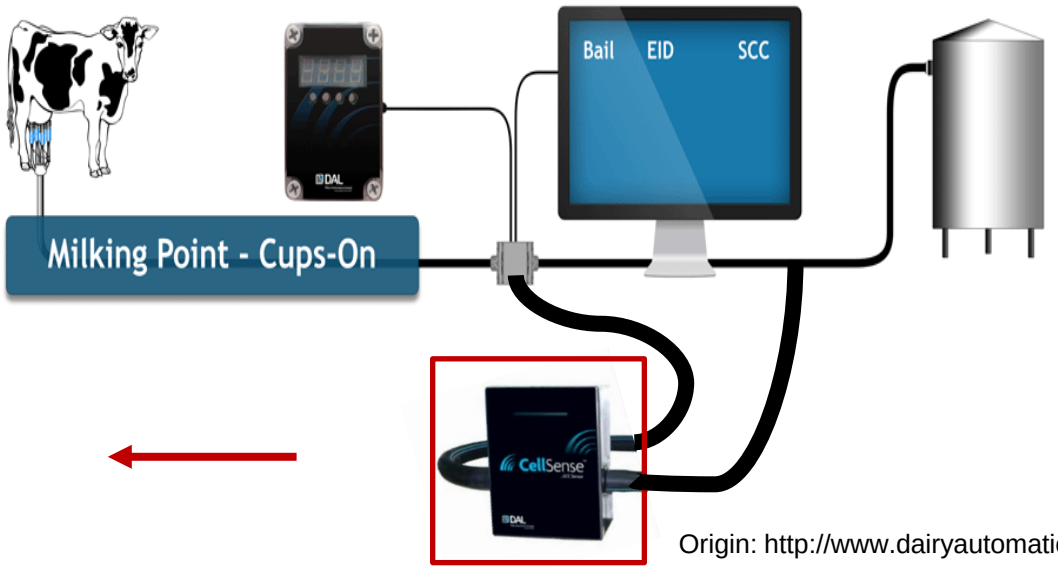
- Calibration and validation of sensor systems is necessary

- **Aim of the study**
  → statistical calibration of the sensor system **CellSense™**
  *(Sensortec, Hamilton / Dairy Automation Limited, Waikato, New Zealand)*

# CellSense™

- Examination of the aptitude for udder health monitoring
- Automated California Mastitis Test (CMT) *(Whyte et al., 2004)*
- 7 sensors installed in rotary milking parlour (*GEA Farm Technologies*)
- Measurement of viscosity in a milk sample ’ **Drain time** (in sec)




Origin: http://www.dairyautomation.co.nz/

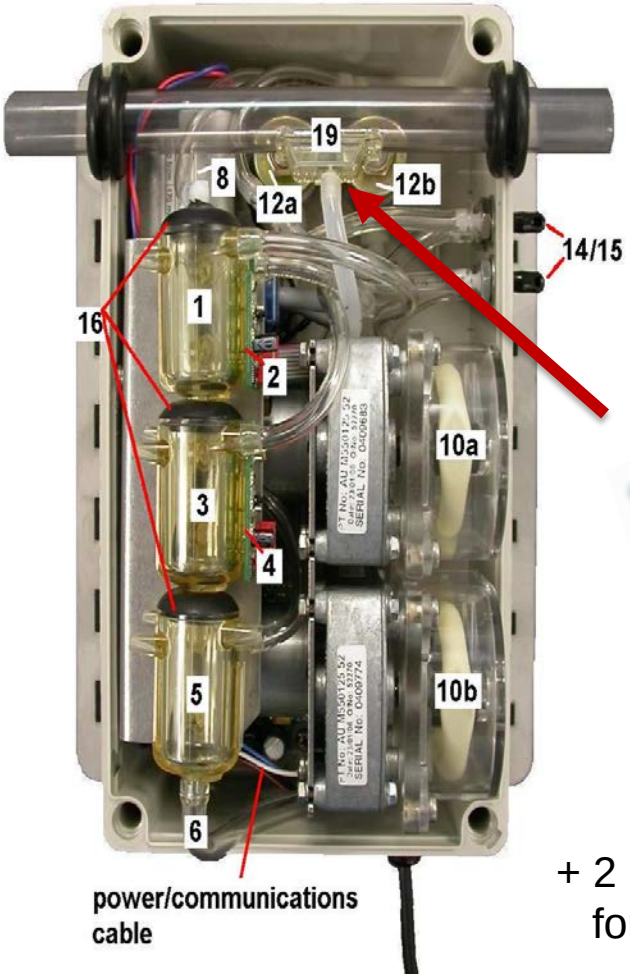
# Material & methods

**Experimental setup for the sensor calibration**

- **2** similar tests in 6-month period
- **3** original milk samples were chosen for each test, because of laboratory-determined SCC informations a day before (official milk recording)
- Consisting of these 3 original milk samples,
  **9** mixed milk samples were mixed within a serial dilution

# Material & methods

## Experimental setup for the sensor calibration




**19** sampling well-tube that mounts directly onto the milk-line ’ removing from milk-line and connecting with syringe with 60ml milksample inside


+ 2 reference specimens of every sample for the laboratory to analyse (n = 18)

# Material & methods

## Calibration data set – Descriptive statistics

| | N | Median | Mean | Std | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **CellSense™** | | | | | | |
| Drain time (sec) | 504 | 1.94 | 2.01 | 0.36 | 1.33 | 3.67 |
| Sensor-SCC (1000/ml) | 504 | 364 | 437 | 358 | 0 | 2,111 |
| Log-transformed drain time (sec)* | 504 | 1.29 | 1.30 | 0.07 | 1.13 | 1.56 |
| **Laboratory** | | | | | | |
| SCC (1000/ml) | 504 | 679 | 855 | 641 | 45 | 2,597 |
| SCS** | 504 | 5.76 | 5.70 | 1.22 | 1.85 | 7.70 |

*log10(drain time)+1; **log2 (SCC/100) +3

# Material & methods

## Calibration data set – Sensor effects & repeatability

- For the estimation of the sensor effects a linear mixed model was used:

$$Y_{ij} = \mu + SENSOR_i + sr_j + e_{ij}$$

with

| | |
|---|---|
| $Y_i$ | = observation of the log-transformed drain time |
| $\mu$ | = overall mean |
| $SENSOR_i$ | = fixed effect of the i-th sensor (i = 1,…, 7) |
| $sr_j$ | = sample run of the j-th sample (j = 1,…, 4) |
| $e_i$ | = random residual of the i-th observation |

- Repeatability for the 4-times measured samples:

$$w^2 = \tilde{A}^2_{\text{sample run}} / (\tilde{A}^2_{\text{sample run}} + \tilde{A}^2_{e})$$

# Results - Calibration data set

- Repeatability: w = 0.92

- Correlations:

| | | Drain time | Sensor-SCC | Log-transformed drain time |
|---|---|---|---|---|
| Calibration data set* | SCS | 0.75 | 0.74 | 0.79 |
| Leslie et al. (2007) | | - | 0.71 | - |
| Kamphuis et al. (2008) | | - | 0.76 | 0.82 |

*p<.0001

# Results - Calibration data set

**Statistical calibration with a regression function**

$$SCS = a + b_1 * (logDT) + b_2 * (logDT)^2$$

with

| | | |
|---|---|---|
| SCS | = | Somatic Cell Score |
| a | = | intercept |
| b | = | slope |
| logDT | = | log-transformed drain time |
| $logDT^2$ | = | sqared log-transformed drain time |

| | Sensor 1 | Sensor 2 | Sensor 3 | Sensor 4 | Sensor 5 | Sensor 6 | Sensor 7 |
|---|---|---|---|---|---|---|---|
| $R^2$ (%) | 87.2 | 60.3 | 56.1 | 77.5 | 71.4 | 76.2 | 81.5 |
| a | -131 | -73 | -36 | -120 | -121 | -93 | -124 |
| $b_1$ | 190 | 106 | 50 | 174 | 178 | 134 | 179 |
| $b_2$ | -65 | -35 | -14 | -59 | -61 | -45 | -61 |

# Results – Validation data set

**Validation with the measured data between both tests**

$$\widehat{VFV} = a + b_1 * (logDT) + b_2 * (logDT)^2$$

| | | |
|---|---|---|
| with | $\widehat{VFV}$ | = predicted SCS |
| | a | = intercept |
| | b | = slope |
| | logDT | = log-transformed drain time |
| | $logDT^2$ | = sqared log-transformed drain time |

- Correlation between $\widehat{VFV}$ and SCS: **r = 0.56**

# Conclusion

- Sensors had a significant effect on the log-transformed drain time ($p<.0001$)
- Repeatability was high with $w = 0.92$
- Correlations in the literature support our present findings
- Correlation between $\widehat{VFV}$ and SCS was unfortunately low with $r = 0.56$
- Explanations?
  - f. e. different milk fractions analysed by sensor and laboratory

# Acknowledgment

We gratefully acknowledge the financial support
and the cooperation within the project
**„Innovative procedures of the performance test of dairy cattle as the base of the modern breeding programme from the Nord-Ost-Genetic“**

**Cooperation partner:**

- Martin-Luther-Universität Halle-Wittenberg
- NORD-OST GENETIC GmbH & Co. KG
- Landesforschungsanstalt für Landwirtschaft und Fischerei MV
- Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie
- Leibniz-Institut für Nutztierbiologie

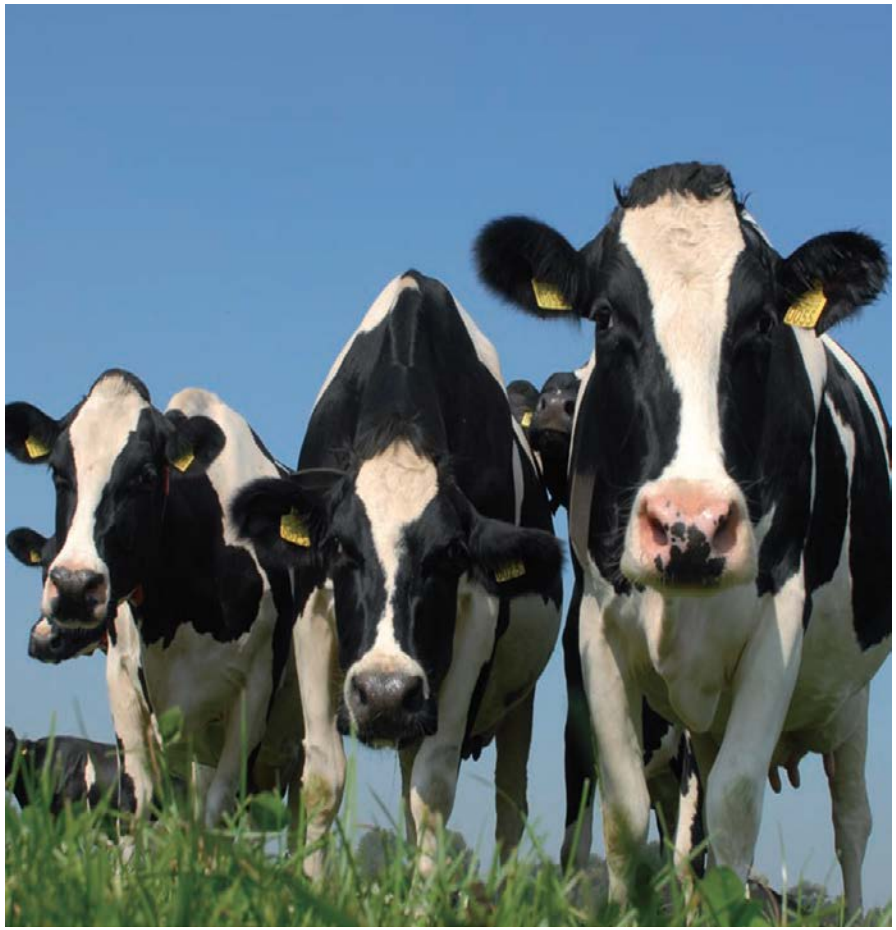
**Sponsored by the Federal Institute for agriculture and nutrition**

**within the promoting innovation**

Bundesanstalt für
Landwirtschaft und Ernährung

Bundesministerium für
Ernährung, Landwirtschaft
und Verbraucherschutz

# Thank you for your kind attention!



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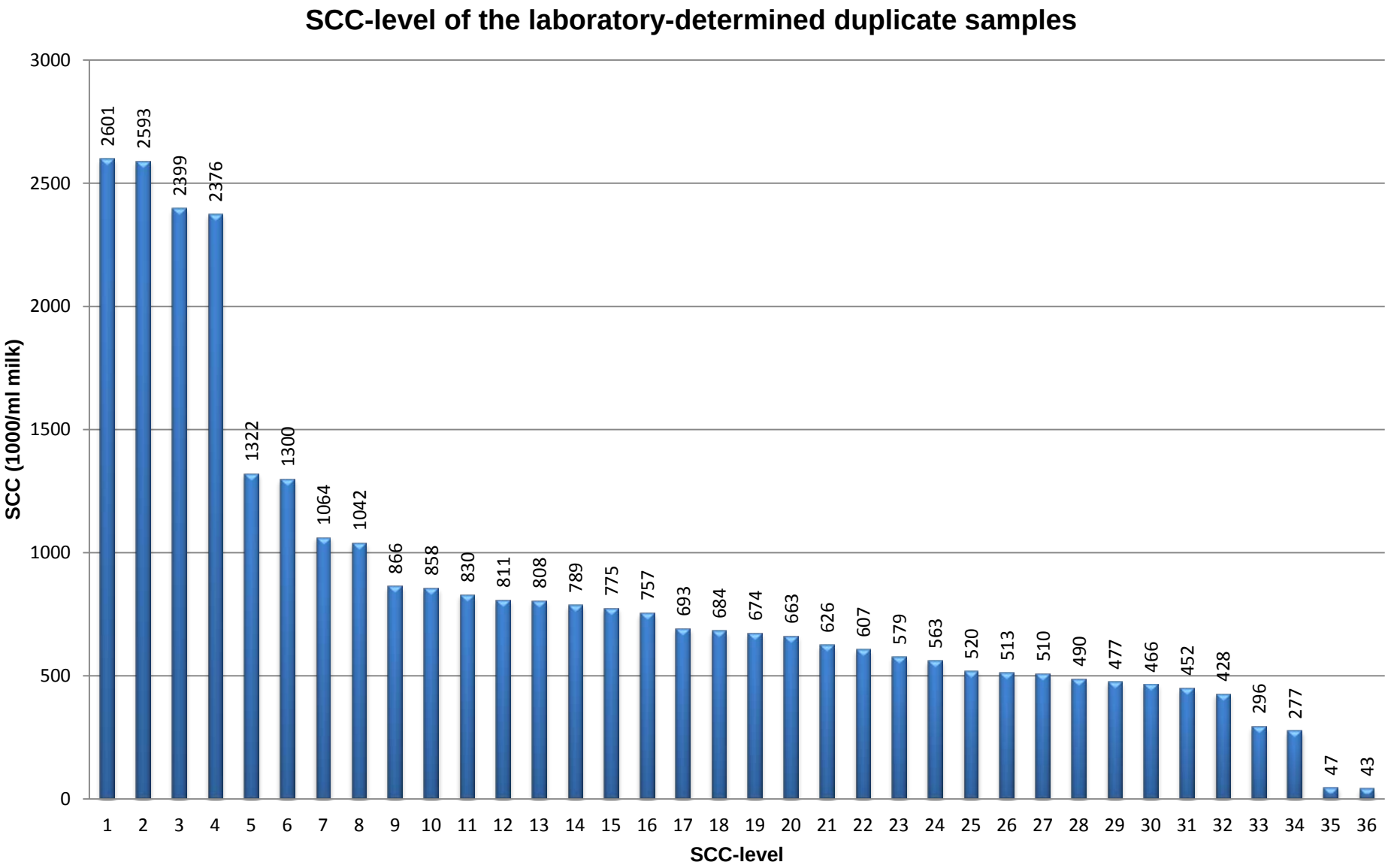
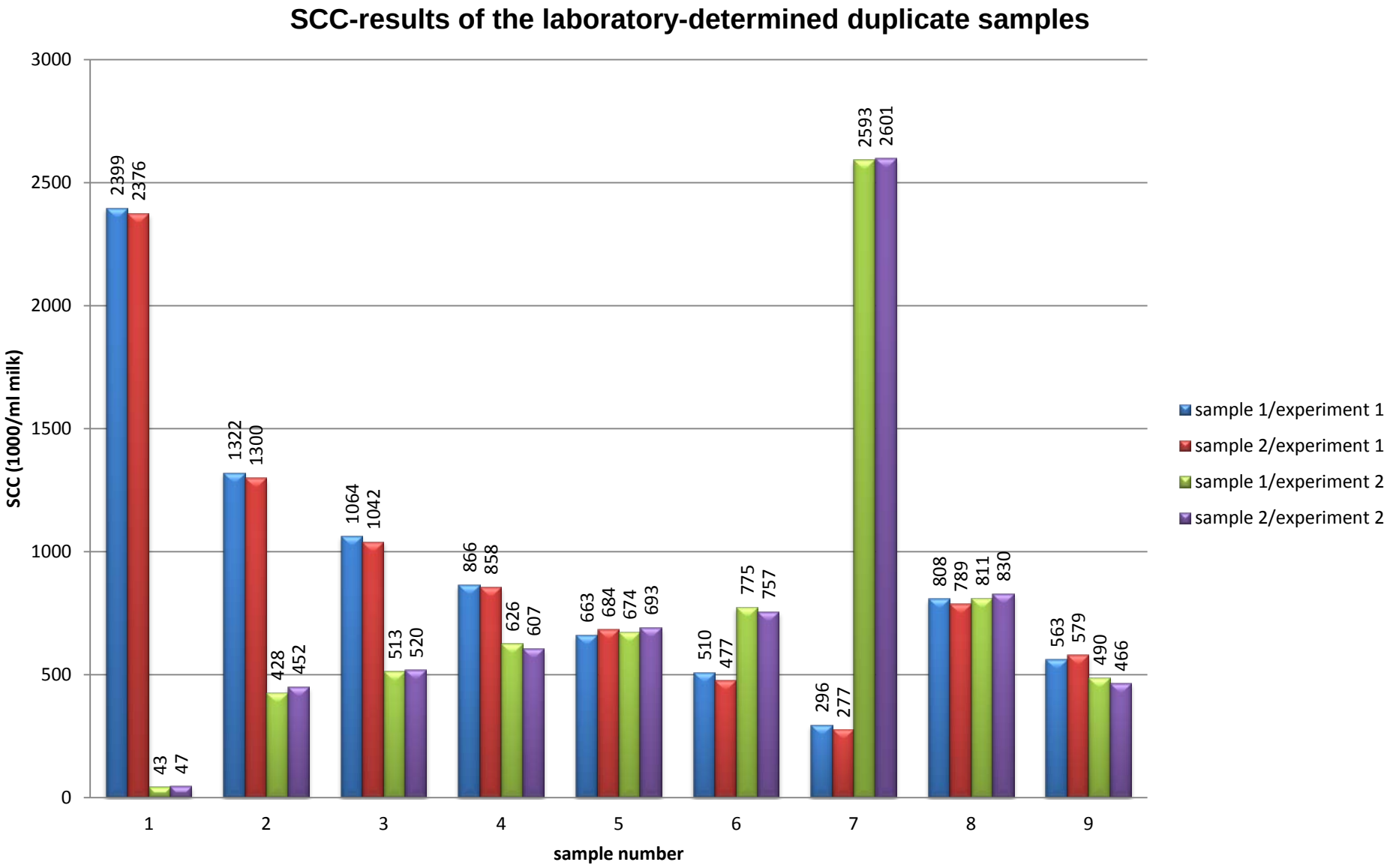
www.http://www.dairyautomation.co.nz/

# Annex


SCC-level of the laboratory-determined duplicate samples
SCC (1000/ml milk)
SCC-level
3000
2500
2000
1500
1000
500
0
2601
2593
2399
2376
1322
1300
1064
1042
866
858
830
811
808
789
775
757
693
684
674
663
626
607
579
563
520
513
510
490
477
466
452
428
296
277
47
43
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

# Annex


SCC-results of the laboratory-determined duplicate samples
SCC (1000/ml milk)
sample number
sample 1/experiment 1
sample 2/experiment 1
sample 1/experiment 2
sample 2/experiment 2
0
500
1000
1500
2000
2500
3000
1
2
3
4
5
6
7
8
9
2399
2376
43
47
1322
1300
428
452
1064
1042
513
520
866
858
626
607
663
684
674
693
510
477
775
757
296
277
2593
2601
808
789
811
830
563
579
490
466

# Annex

**2 cows with high SCC milk**

**2 cows with low SCC milk**

Preparation of a serial dilution (f.e. experiment 1):

*1. step* *Sample run with one sensor*

- milk of cow 4131 ’ 4 red lights
- milk of cow 4138 ’ 2 / 3 orange lights (**milk 3**)
- milk of cow 5042 ’ 1 green light
- milk of cow 5040 ’ 1 green light (**milk 2**)

*2. step* *Serial dilution with milk of cow 4131 & 5040*

- 30ml (of 4131) + 30ml (of 5040)

’ if there are >2 mio. somatic cells in milk of cow 4131

’ 4 red lights!

*3. step*

- 30ml (of 4131/5040) + 30ml (of 5040)

’ about 33% of the milk of cow 4131 in the assay

’ 2 orange lights! (**milk 1**)

*4. step* *Preparing the serial dilution with 3 milk samples*

# Annex

- Serial dilution:

***experiment 1***

| sample | ration (%) | | weight (g) | | sample | ratio (%) | | weight (g) | |
|---|---|---|---|---|---|---|---|---|---|
| | milk 1 | milk 2 | milk 1 | milk 2 | | milk 3 | milk 2 | milk 3 | milk 2 |
| 1 | 100 | – | 1000 | – | 8 | 100 | – | 1000 | – |
| 2 | 50 | 50 | 516 | 516 | 9 | 50 | 50 | 500 | 525 |
| 3 | 60 | 40 | 655 | 437 | | | | | |
| 4 | 70 | 30 | 701 | 303 | | | | | |
| 5 | 80 | 20 | 804 | 202 | | | | | |
| 6 | 90 | 10 | 905 | 104 | | | | | |
| 7 | – | 100 | – | 1000 | | | | | |

***experiment 2***

| sample | ratio (%) | | weight (g) | | sample | ratio (%) | | weight (g) | |
|---|---|---|---|---|---|---|---|---|---|
| | milk 1 | milk 2 | milk 1 | milk 2 | | milk 3 | milk 2 | milk 3 | milk 2 |
| 1 | – | 100 | – | 1000 | 8 | 100 | – | 1000 | – |
| 2 | 50 | 50 | 500 | 500 | 9 | 50 | 50 | 500 | 500 |
| 3 | 60 | 40 | 600 | 400 | | | | | |
| 4 | 70 | 30 | 700 | 300 | | | | | |
| 5 | 80 | 20 | 800 | 200 | | | | | |
| 6 | 90 | 10 | 900 | 100 | | | | | |
| 7 | 100 | – | 1000 | – | | | | | |

# Annex

| | N | Median | Mean | Std | Minimum | Maximum |
|---|---|---|---|---|---|---|
| $\widehat{SCS}$ | 1357 | **2.54** | **2.81** | **1.65** | **-6.23** | **7.72** |
| SCS | 1357 | 2.16 | 2.45 | 1.66 | -1.32 | 8.98 |

| | Drain time | LogDT | SCC | SCS |
|---|---|---|---|---|
| $\widehat{SCS}$* | **0.77** | **0.87** | **0.37** | **0.56** |
| SCS | 0.57 | 0.61 | 0.66 | - |

*p < .0001