Assuring accuracy in milk recording analysis on-farm

- Approach on principles for guidelines -

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INTRODUCTION

On-farm milk analysis a new major issue for milk recording:

⇒ An increased number of portable analytical devices available for on-farm milk analysis at-line

⇒ First in-line analytical devices available or under development

ON-FARM MILK ANALYTICAL DEVICES

Milk composition

Mid infra red analytical devices

Ultrasonic analytical devices

Light scattering & al

Somatic cell counting

Flow cytometry

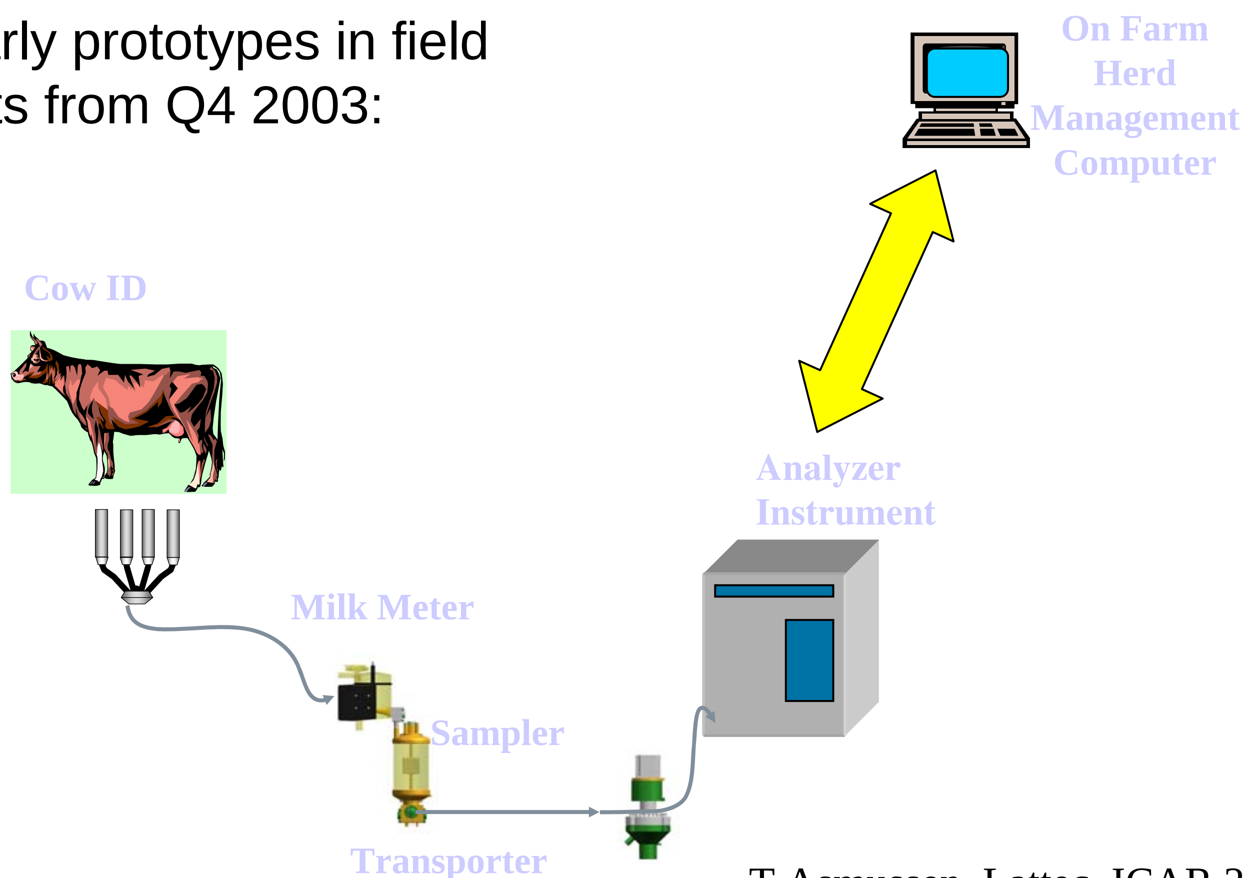
Cell/Slide cytometry

Viscosimetry

On-farm / at-line analysers

Herd management system - example MERKUR project

•Early prototypes in field tests from Q4 2003:



T Asmussen, Lattec, ICAR 2004, Sousse

MIRIS SA, Sweden

www.miris.se

mid-infrared (MIR)

Miris analytical instruments are used for analyzing aqueous solutions. The technology is based on **mid - infrared (MIR)** transmission spectroscopy.

- Robust construction without any moving parts
- High operational reliability
- Easy to use
- Broad application area
- Competitive pricing
- Environmentally-adapted analyses
- High measuring accuracy and precision
- Certified analytical technology

LactiCheck LC-02 (Ultrasonic)

Page & Pedersen International Ltd., USA www.pagepedersen.net

An exciting ultrasonic spectroscopic method for rapid, reliable milk composition results! An ultra-friendly, affordable, automated system providing fat, solids not fat, added water and density for both unprocessed and processed fluid milk products. Dual channel instrument is designed to analyze cow or goat milk (optional configuration for sheep or buffalo milk). Excellent correlation with recognized reference methods (both bench chemistry and automated methods) make the LC-02 easily integratable into established operating procedures.

Scope Electric, Bulgaria

www.scope-electric.com

Milkoscope (Ultrasonic)

* Proven quality measuring module
* Robust protective casing
* Improved accuracy
* Tested repeatability
* LCD for easier operation and controls
* Multi angle probe mechanism
* Connectivity to PC and printer

Fat	0.01 to 25.00%	±0.04%
Protein	2.00 to 7.00%	±0.1%
Lactose	0.01 to 6.00%	±0.1%
SNF	3.00 to 15.00%	±0.1%
Freezing Point	0 to -1°C	±0.005%

Dimensions
W x D x H: 125 x 270 x 265 mm
Weight 3.0 kg

MILKOTRONIC, Bulgaria

www.milkotronic.com

Lactoscan SA (Ultrasonic)

Environmental Conditions:

Ambient air temperature: 10°C to 40°C (option 43 °C)

Milk temperature: 1°C to 40°C

Relative humidity: 30% – 80%

Fat	0,01– 25% (option 45%) ±0,1%
SNF	3% – 15% ±0,15%
Protein	2% – 7% ±0,15%
Lactose	0,01% – 6% ±0,2%
Freezing point	–0,4°C — –0,7°C ±0,001%
Solids	4% – 15% ±0,05%
PH	0 – 14 ±0,05%
Conductivity	3 – 14 [mS/cm] ±0,05%

Kostip, Russia www.kostip.com

Lactan (Ultrasonic)

Tester for determining the parameters of milk composition LACTAN 1-4-200 is intended for determining the mass fraction of fat, protein, nonfat dry matter (NFDM) and density in the sample of whole fresh or preserved milk, and also the presence of added water.

Fat, %	0,5…9,0 ± 0,1
Protein, %	0,5…6,0 ± 0,17
SNF, %	6…12 ± 0,2
Density, g/ml	1000…1080 ± 0,3
Dimensions, mm	270x215x95

Kostip, Russia www.kostip.com

Somatos (viscosimetric)

Somatos is an unique instrument, which can be used on dairy farms due to cheapness, compactness and simplicity in service. Similar instrument, existing on the european market, is ten times more expensive and can be used only in large regional milk testing laboratories. The instrument has high accuracy and can be used beside dairy farms in local veterinary laboratories, test centres of farmers' cooperatives and on dairy factories.

Anameth, France

Anameth SCE (Flow cytometry)

Weight 15 kg

Air tight box in polycarbonate

L=50 cm x H=40 cm x W=20 cm)

Power 90 W

Testing time 90 s

Dedicated to the analysis at-line

Chemometec, Denmark

www.chemometec.com

Nucleocounter SCC-100

(cell/slide cytometry)

-measurement range 10,000 SCC/ml to 2,000,000 SCC/ml.

-Easy operation

-30 sec. analysis time

-Calibration free

-No cleaning

-Maintenance and service free

-Portable/compact

-Safe sample handling and disposal

-Excellent reproducibility

DeLaval, Sweden www.delaval.com

DeLaval cell counter DCC **(cell/slide cytometry)**

Size (w x d x h) 235x236x249 mm

Weight 4.1 kg

Working temp. range +10º to +40ºC

Storage temp. Range -20º to +70º

Humidity range 10% to 85% RH

Measuring range 10 000 to 4 000 000 cells/ml

Speed less than one minute after the cassette inserted

Repeatability (typical)

12% at 100 000 cells/ml, 8% at 400 000 cells/ml,
7% at 1 000000 cells/ml

Sample volume Appr. 60 µl in the cassette

Measuring volume Appr. 1 µl in the measuring window

On-farm / in-line analytical devices

Real time in-line analysers

1- Near Infra Red projects (NIR in-line):

* CRA of Lodi, Italy

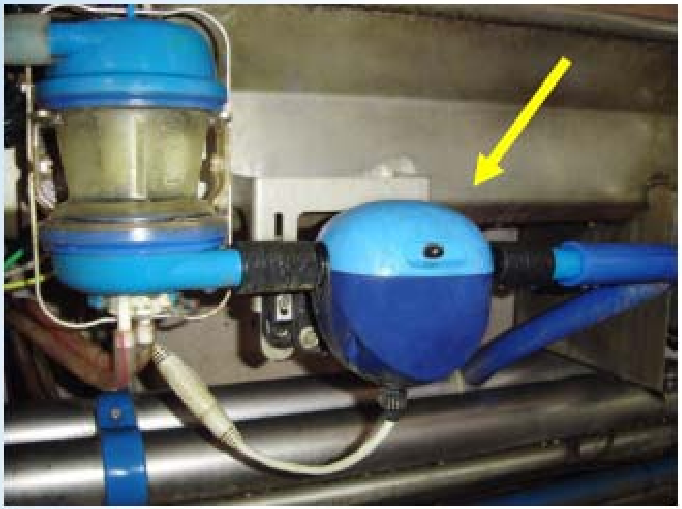
2- AFIMILK : AFILab (Light scattering)

3- DeLaval : Online Cell Counter (OCC)

Real Time Milk Analyzer

The Concept

Automated coupling of the "lab" to each stall in real time at an affordable price



* Free flow
* Non-interfering measurement
* Continuous real time acquisition of milk components
* Data acquired for the individual cow

G Katz & al, Afikim, ADSA 2007, San Antonio TX

DeLaval, Denmark

www.delaval.com

Online cell counter OCC

* DeLaval OCC analyses the SCC of every cow at every milking.

* The cell counting takes a few seconds

* The result is reported on the DeLaval VMS herd management software’s Cow Monitor screen.

* There is no guessing or interpretation of a SCC level. The sample result shows clearly as cells/ml of milk.

Any other devices

… coming ?!!

General concern for milk recording

Defining a proper frame (guidelines) for on-farm analysis

New technical problems :

1- The frame of use : Farm = Less securing environment than lab

- Extreme environment conditions (temperature, moisture/water, shocks, …)
- Less time and analytical expertise in farms and milk recording

2- Harmonisation and precision of analytical data:

- Numerous devices de-located $\Rightarrow$ calibration & quality control
- Lower and different precision (although more possible analysis)

Guidelines needed to provide technical solutions & guidance:

- List cautions and minimum maintenance operations.
- Design a minimum calibration and monitoring system to secure on-farm operations.
- maximum limits of precision and accuracy for validation
- Minimum control number for official milk recording
- Limits for quality control

Outlines of guidelines for OMA

1- Terms and definition

2- Limits for precision and accuracy and correspondence

3- Evaluation for ICAR approval

4- Quality control and calibration

5- Data record and data management

6- Lactation calculation

Principle of establishing limits

Accuracy of measurement devices
must respond to the
need of the milk producer for technical management

⇒ Important to detect what is out of the norme !!!

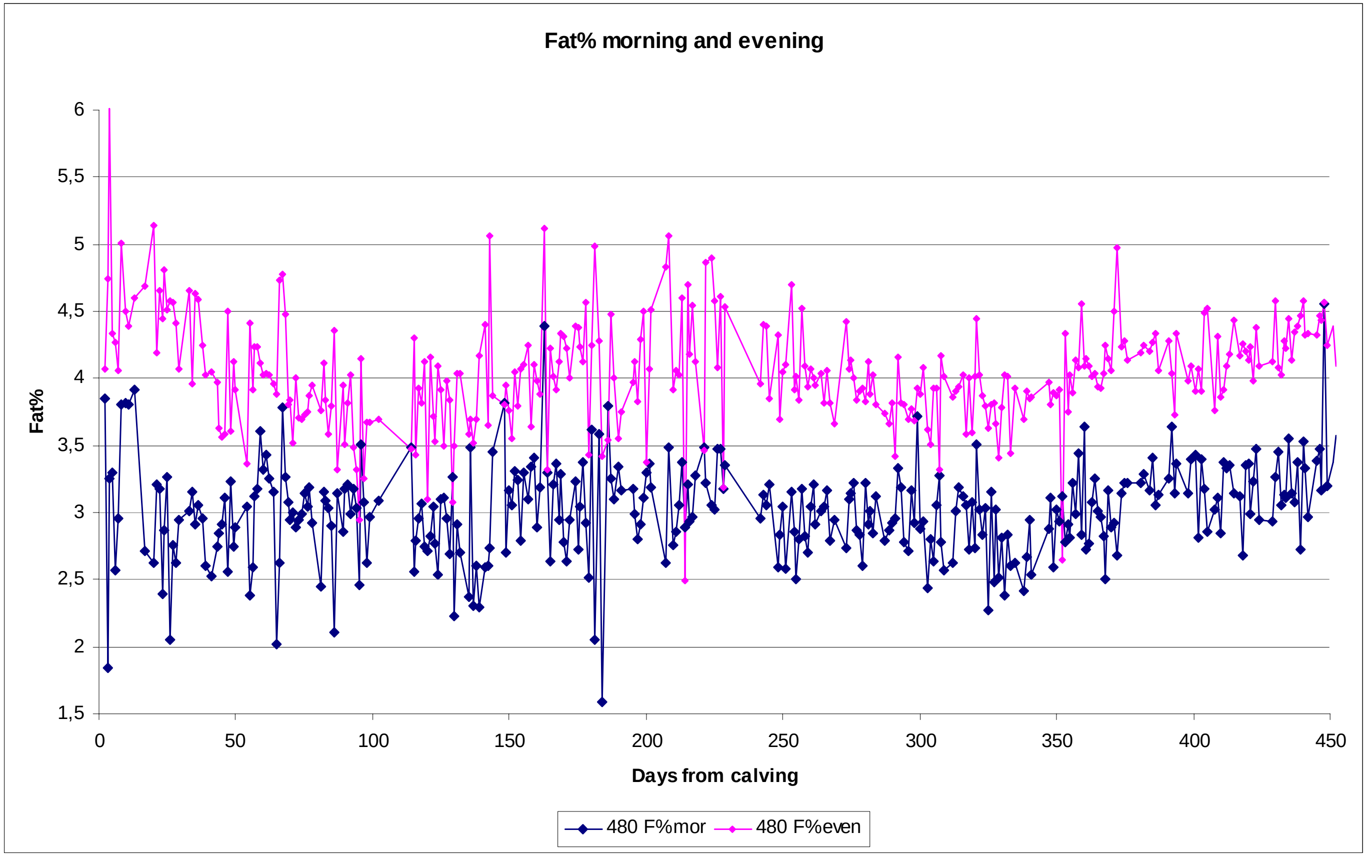
> The norme is the natural day-to-day variation of production

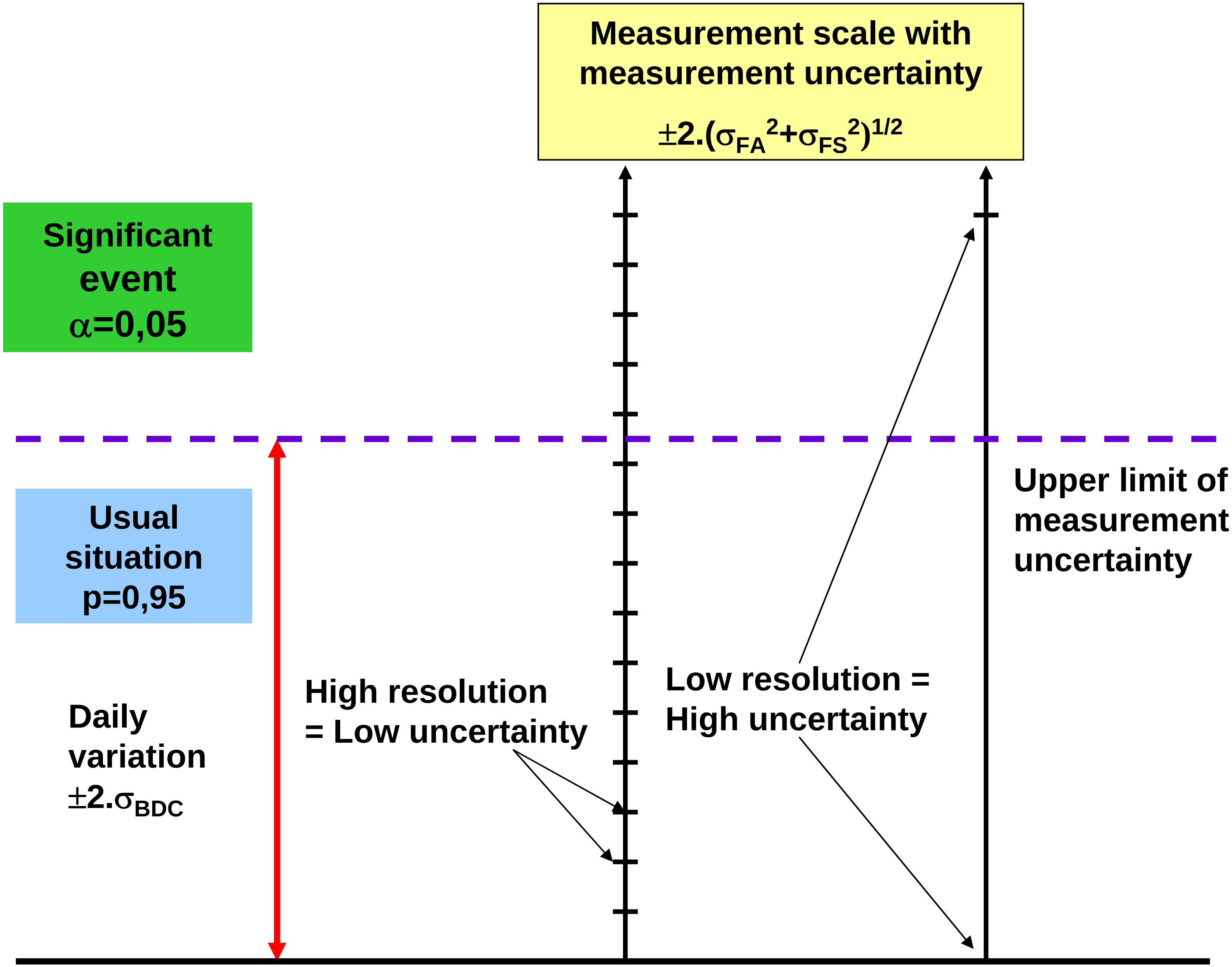
> the informative event is located out of limit of the day-to-day variation

⇒ need = detect/measure significant production changes day after day.

Between day variation of fat concentration for morning and evening milking Example of Cow 480

(Recording data from Peter Lovendahl, Institute of Animal Science, Aarhus University, 2004)




Measurement scale with measurement uncertainty
$\pm 2.(\sigma_{FA}^2+\sigma_{FS}^2)^{1/2}$
Significant event
α=0,05
Usual situation
p=0,95
Daily variation
$\pm 2.\sigma_{BDC}$
High resolution = Low uncertainty
Low resolution = High uncertainty
Upper limit of measurement uncertainty

First step
Evaluate the standard limit of day-to-day variation

Choice is made on FAT

the most fluctuating component

expresses within shortest delays metabolism & health troubles

> Literature gives little information :

Dr. Ellen Young (Utah State University)

$\Rightarrow$ max. range = $\pm$ 0,5 g/100 g or σ_{BDC} = 0,25 g/100 g

> Experiments confirms :

Tove Asmusen (Lattec), Peter Lovendahl & al, Aarhus Univ., 2004)

CV% $\approx$ 6,0-6,5% $\Leftrightarrow$ 0,24-0,26 g/100g at 4,0 g/100g

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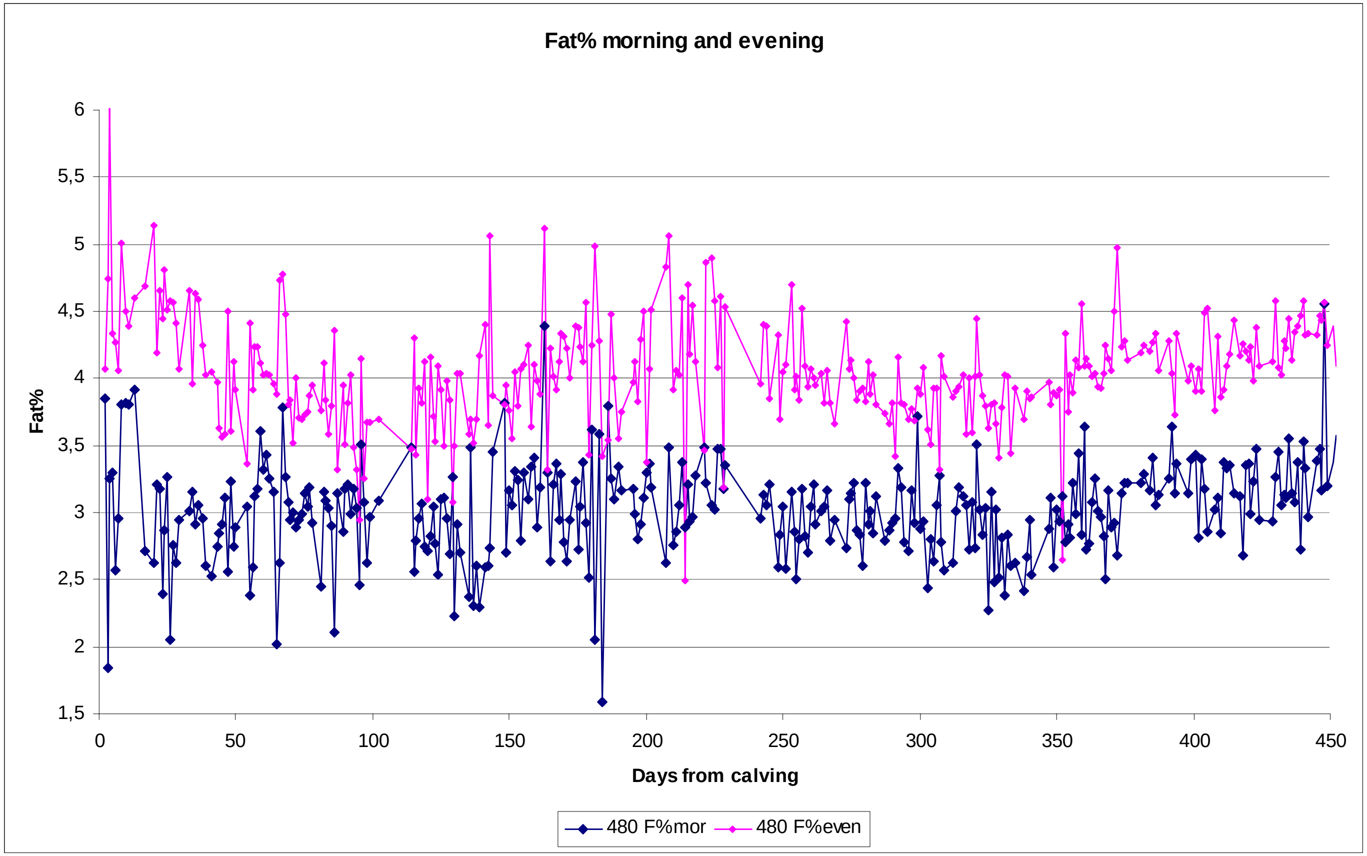

Suitability of a +/- 0,5 % fat belt as limits of natural between day variation of fat concentration - Example of Cow 480

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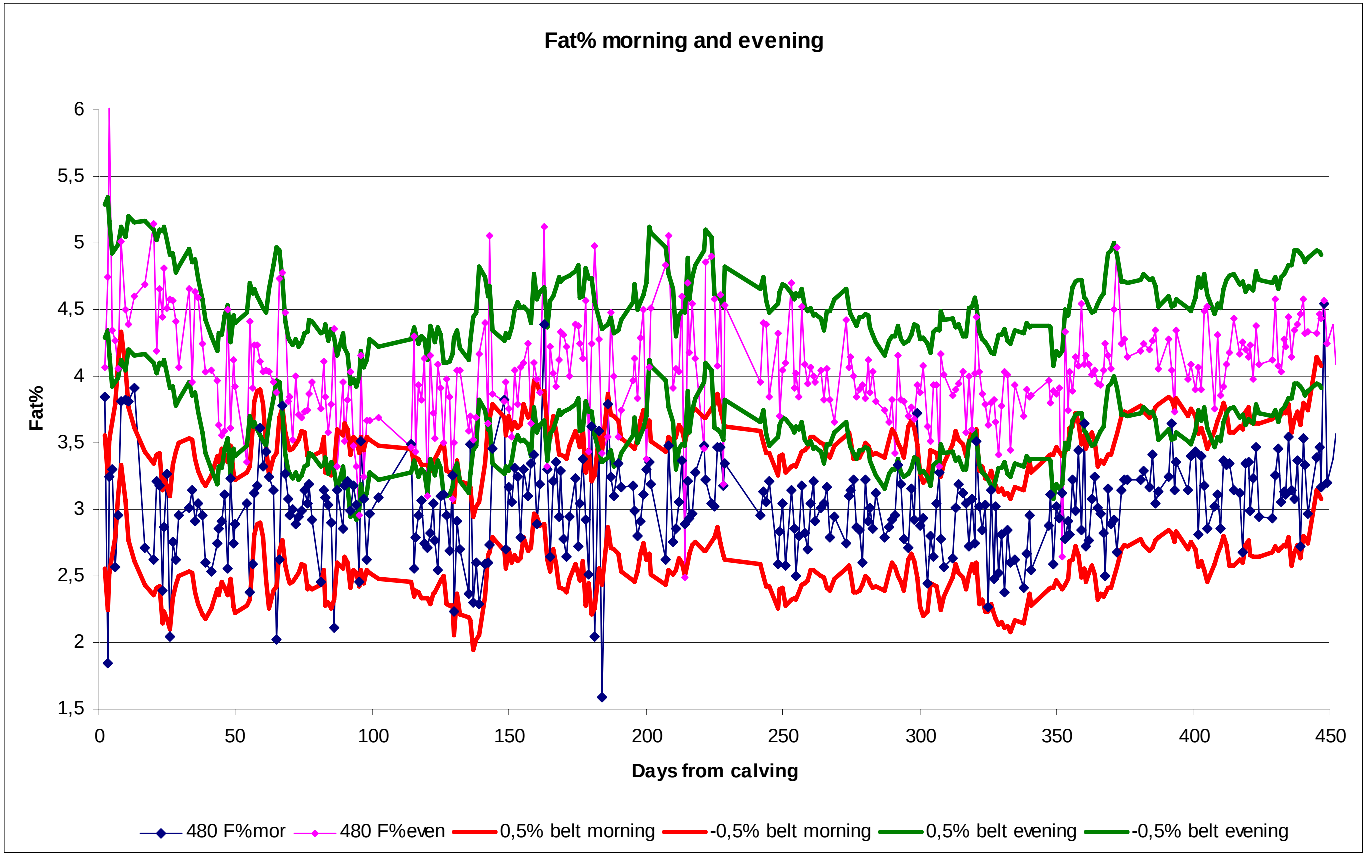
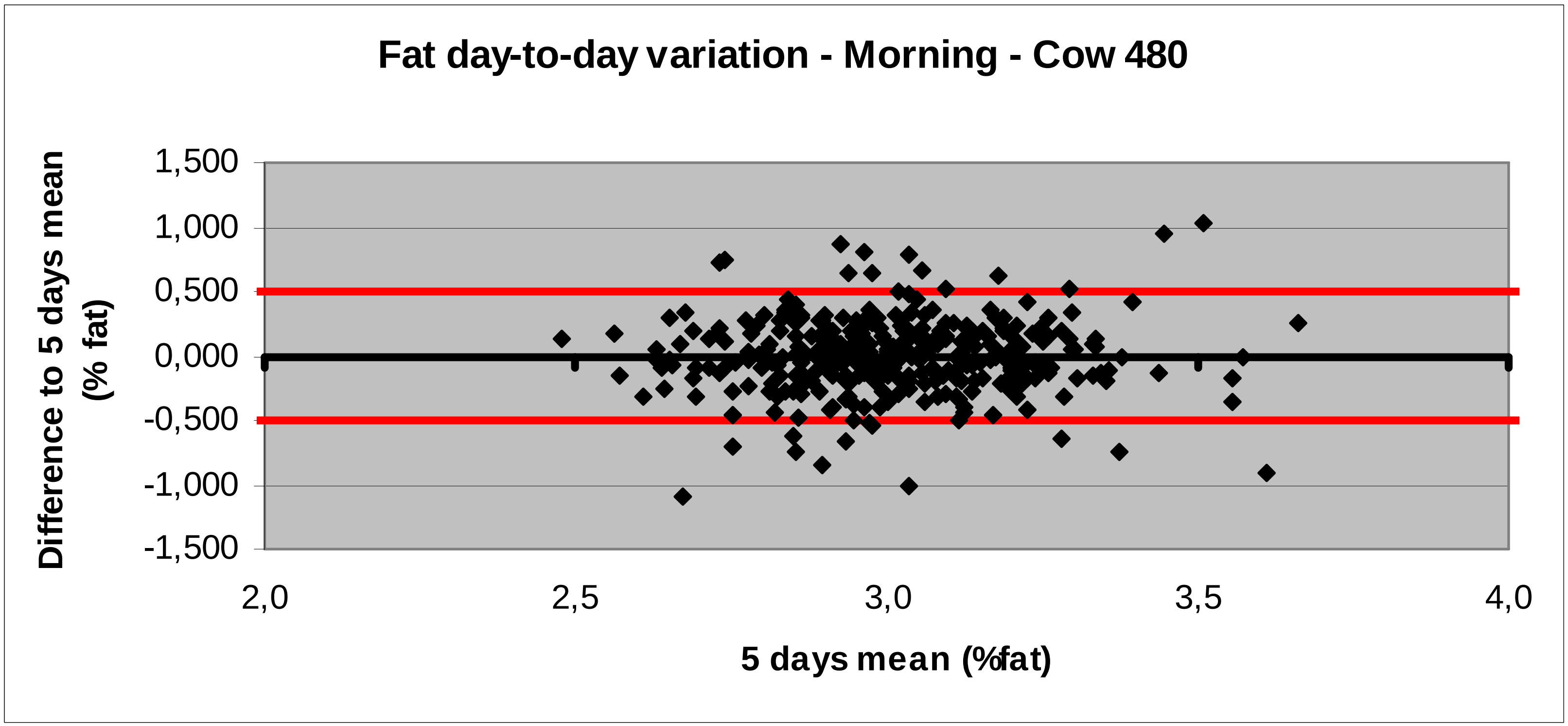


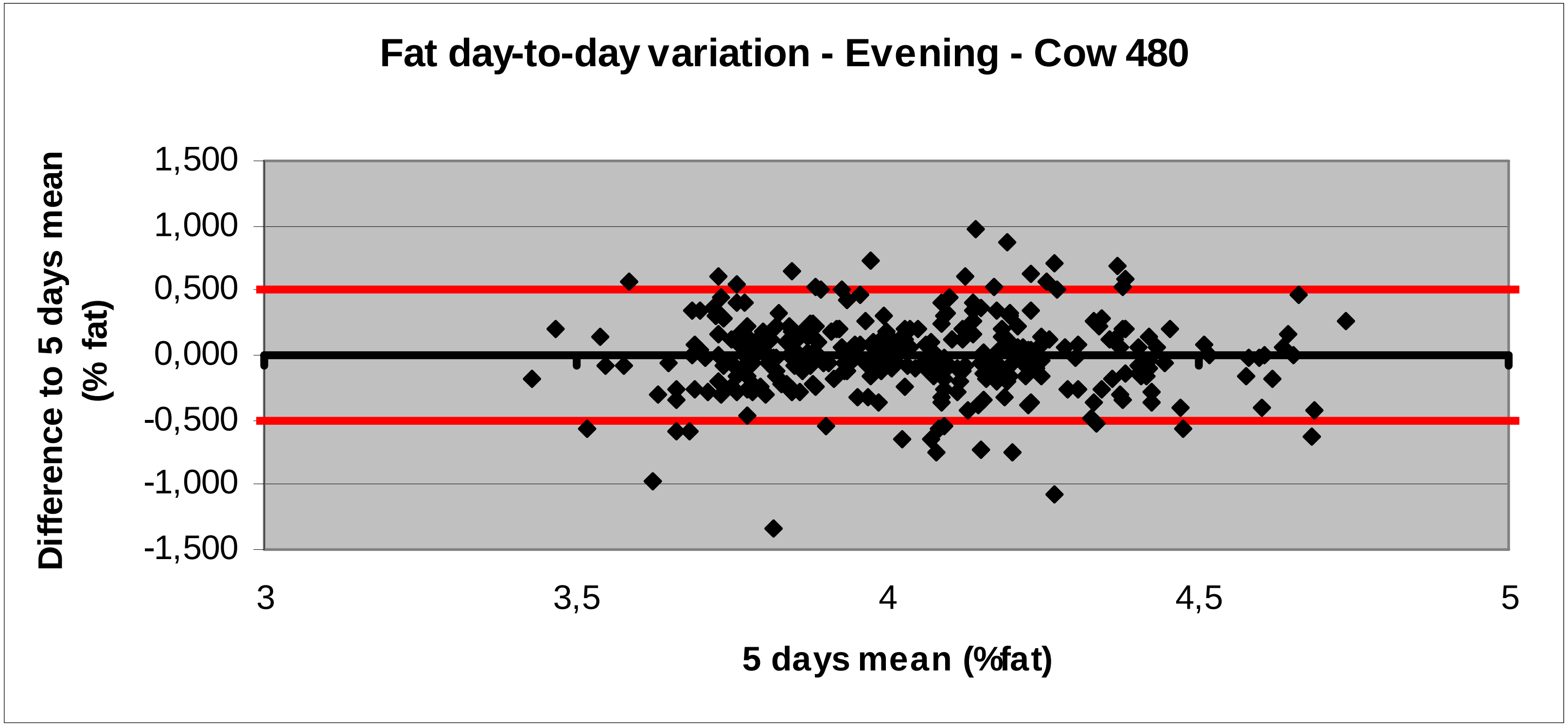
Suitability of a +/- 0,5 % fat belt as limits of natural between day variation of fat concentration - Example of Cow 480 for morning milking

(Recording data from Peter Lovendahl, Institute of Animal Science, Aarhus University, 2004)



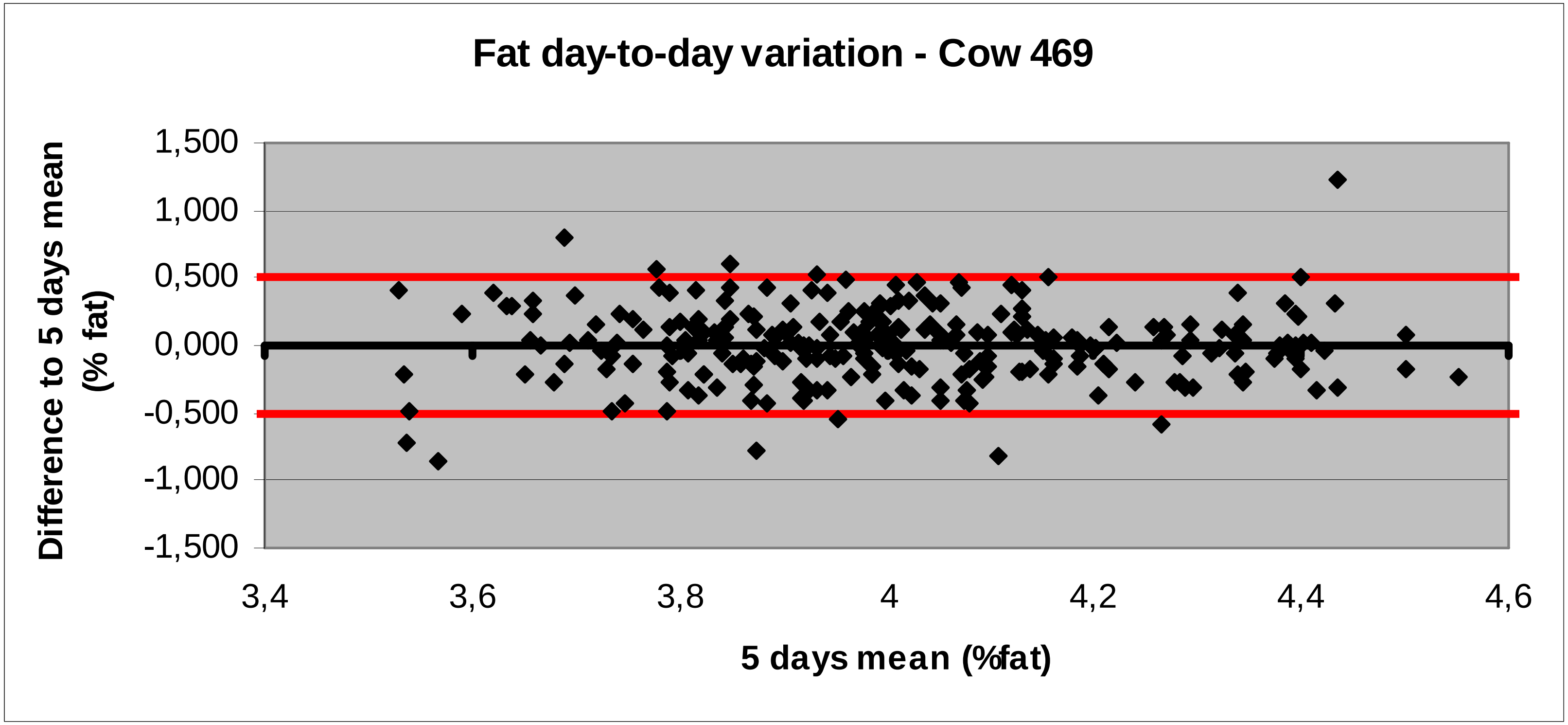
Suitability of a +/- 0,5 % fat belt as limits of natural between day variation of fat concentration - Example of Cow 480 for evening milking

(Recording data from Peter Lovendahl, Institute of Animal Science, Aarhus University, 2004)



Suitability of a +/- 0,5 % fat belt as limits of natural between day variation of fat concentration - Example for the average (morning+evening)/2

(Recording data from Peter Lovendahl, Institute of Animal Science, Aarhus University, 2004)



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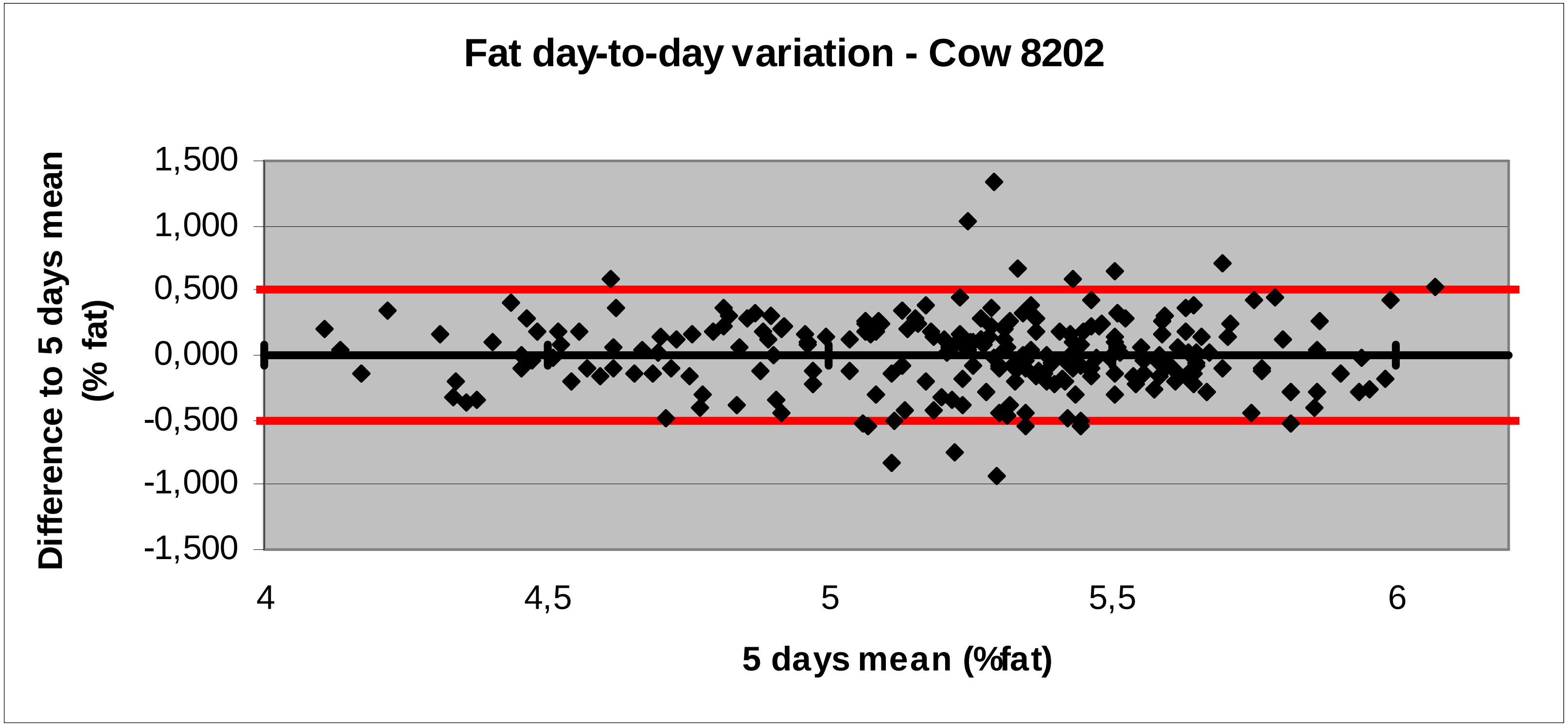

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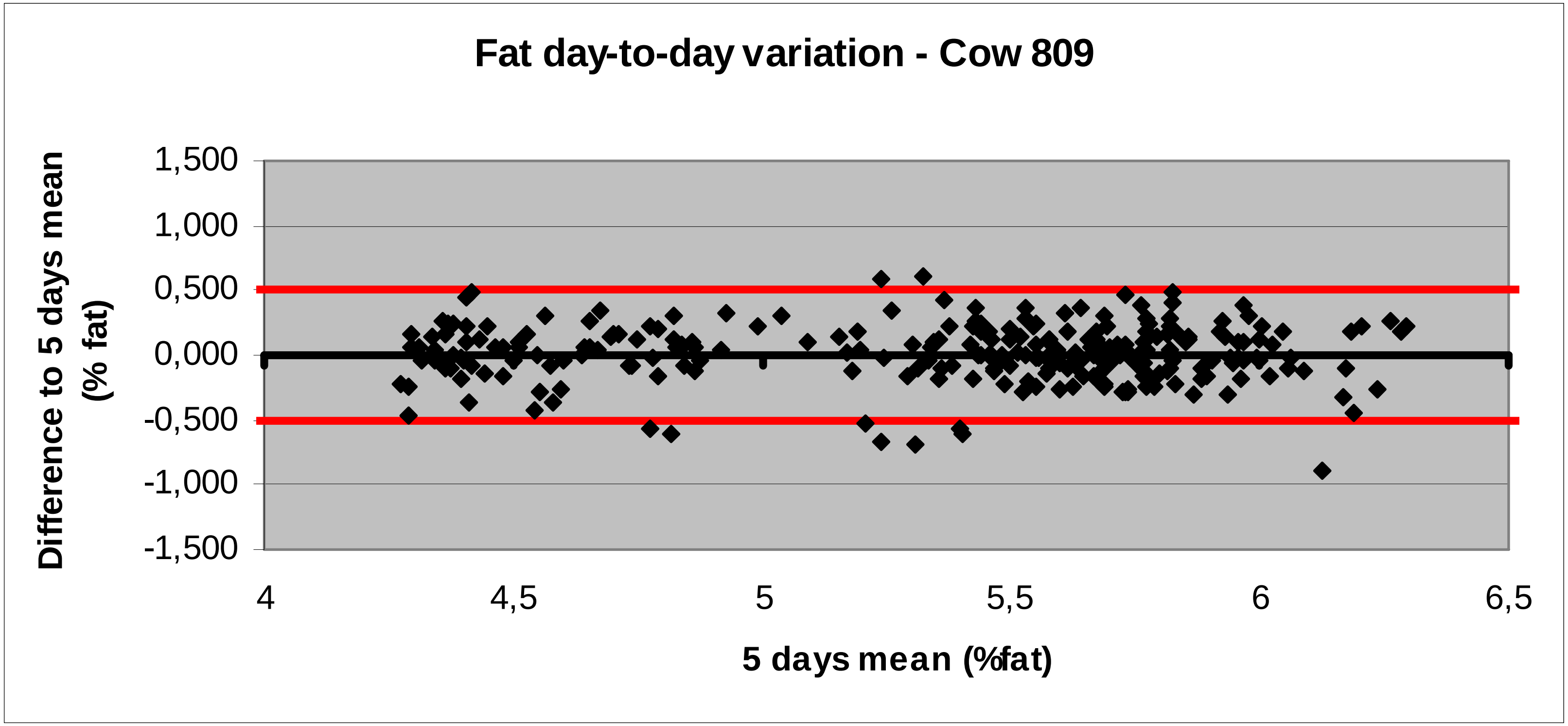

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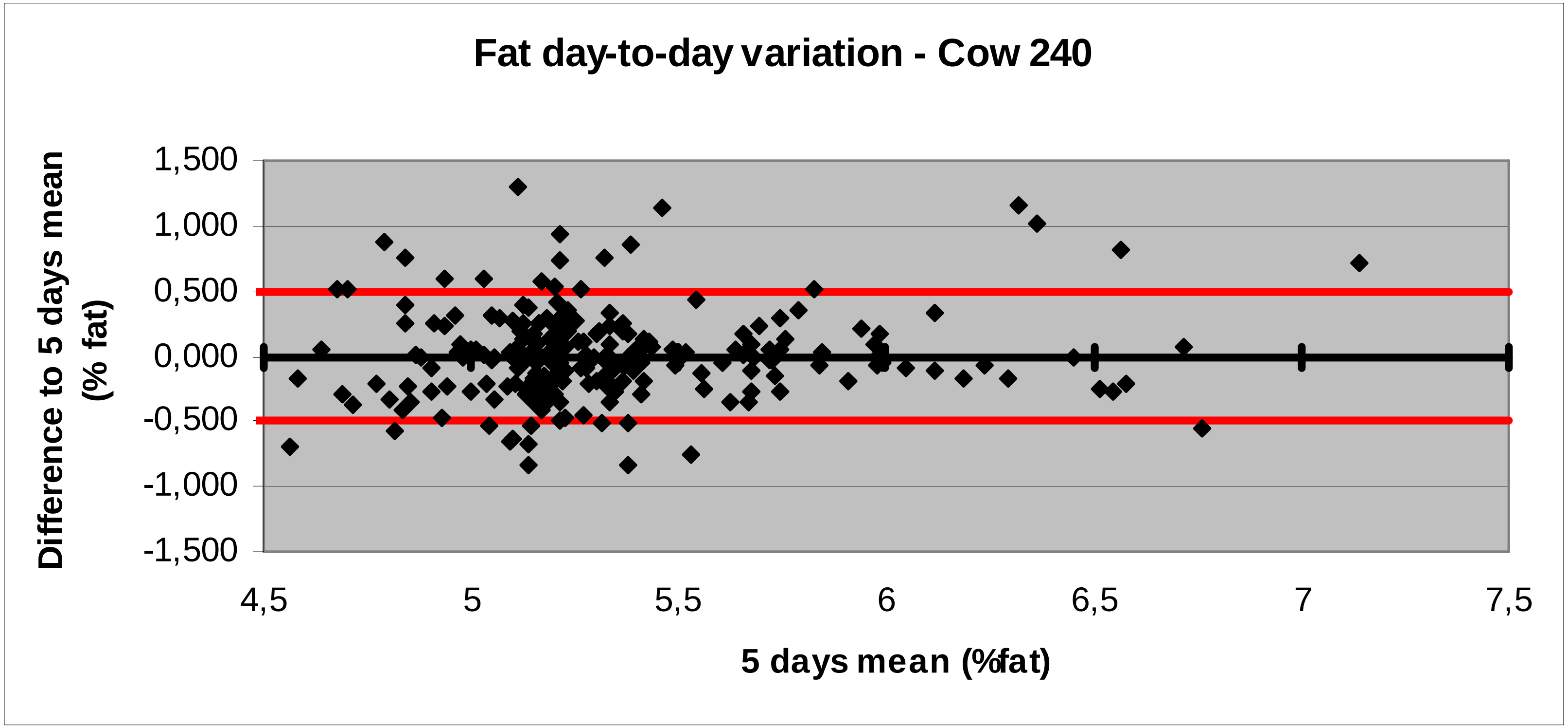

First step
Setting limits of accuracy for OMA

Establish a statistical basis

Milk composition estimate C is expressed by the model

$$C = T + e_{BDC} + e_S + e_A$$

T = Unknown true value

BDC = Between day variation

S = sampling

A = Analysis

The error σ_C of milk composition estimation (e.g. fat%) is :

$$\sigma_C^2 = \sigma_{BDC}^2 + \sigma_S^2 + \sigma_A^2$$

First constraint – The natural production variation

$\Rightarrow$ **Measurement (sampling + analysis) variance**

cannot exceed the natural (day-to-day) variation for the criteria :

$$\sigma_{FA}^2 + \sigma_{FS}^2 \leq \sigma_{BDC}^2 \quad \Leftrightarrow \quad \sigma_{FA} \leq (\sigma_{BDC}^2 - \sigma_{FS}^2)^{1/2}$$

For in-line RT devices, no sampling $\Rightarrow$ $\sigma_{FA} \leq \sigma_{BDC}$

(Subscript F indicates on-farm; subscript L indicates at-lab)

FAT is used as a basis for calculation :

From experimental data : ***Limit*** $L\sigma_{BDC}$ ***= 0,25 g/100 g***

From ICAR guidelines : ***Limit*** $L\sigma_{FS}$ ***= 0,103 g/100 g,***

$\Rightarrow$ ***At-line:*** $L\sigma_{FA}$ = ***0,22 g/100 g***

$\Rightarrow$ ***In-line:*** $L\sigma_{FA}$ = ***0,25 g/100 g***

Second constraint – Analytical accuracy at the laboratory

1- For genetic evaluation : **preserve congruence and equivalence** with existing milk recording data with laboratories (past and present)

$\Rightarrow$ **uncertainty of measurement at least equivalent** to that of the classical system using regular milk sampling and testing in laboratory.

The number $\mathbf{N = n_{FA}/n_{LA}}$ **the multiplication factor enabling for equivalence for genetic purpose**

as used to calculate **the adequate sampling number $\mathbf{n_{FA}}$ on-farm** from **the usual recording number $\mathbf{n_{LA}}$**

It is obtained through $$N \geq (2.\sigma_{BDC}^2)/(\sigma_{BDC}^2 + \sigma_{LS}^2 + \sigma_{LA}^2)$$

From the limits for FAT of ICAR Guidelines N $\geq$ 1,5 $\Rightarrow$ N = 2

Example: **15** different records needed to equal uncertainty of **10** usual records

Second constraint – Analytical accuracy at the laboratory

2- For comparability between analytical systems:

preserve congruence and equivalence with laboratory milk analysers

$\Rightarrow$ Allow defining conditions of **equivalent final uncertainty** with laboratory analysers.

Expressed by

a- the factors of equivalence FE

to be used to calculate the maximum limits for analyser evaluation and QC

b- Sampling replicate numbers Ne

the minimum number enabling analytical accuracy equivalent to lab analysis

> the equivalence factors $FE = L\sigma_{FA} / L\sigma_{LA}$

or $FE = [(L\sigma_{BDC}^2 - L\sigma_{FS}^2)]^{1/2} / L\sigma_{LA}$

FE the ratio of accuracy on-farm vs accuracy at lab

> the equivalence sampling number $N = FE^2$

since $\sigma_{FA}^2 / n_{FA} \leq \sigma_{LA}^2 \Leftrightarrow n_{FA} \leq (\sigma_{FA} / \sigma_{LA})^2$

From limits for FAT of ICAR Guidelines:

FE = 2,2 rounded to 2 $\Rightarrow$ **$Ne \geq 4$ for at-line analysis**

FE = 2,5 $\Rightarrow$ **$Ne \geq 6$ for in-line analysis**

3 categories of analysers (classes) according to accuracy defined through FE

Class 1 :	**Laboratory analysers**	**FE = 1**
Class 2 :	**on-farm/at-line analysers**	**FE = 2**
Class 3 :	**on-farm/in-line analysers**	**FE = 2,5**

ICAR Guidelines for milk analyser evaluation and quality control are then applicable

provided - **adequate limits for statistical parameters of accuracy**

- **special adaptation for in-line / real time analysers**

Example of possible limits for evaluation and QC

Milk analytical devices		**Laboratory**			**On-farm At-line**			**On-farm In-line**		
Equivalence Factor	**FE**	**x 1**			**x 2**			**x 2,5**		
Component		**F-P-L**	**Urea**	**SCC**	**F-P-L**	**Urea**	**SCC**	**F-P-L**	**Urea**	**SCC**
Units		g/ 100 g	mg/ 100 g	p. cent	g/ 100 g	mg/ 100 g	p. cent	g/ 100 g [a]	mg/ 100 g [a]	p. cent [a]
Repeatability										
Standard deviation *(sr)*	- Total range			4%			8%			10%
	- Low			8%			16%			20%
	- Medium	0,014	1,4	4%	0,028	2,8	8%	0,035	3,5	10%
	- High	0,028	2,8	2%			4%			5%
Within lab reproducibility										
Standard deviation *(sR)*	- Total range			5%			10%			13%
	- Low			10%			20%			25%
	- Medium	0,028	2,8	5%	0,056	5,6	10%	0,069	6,9	13%
	- High	0,056	5,6	2,50%	0,056	5,6	5%	0,070	7,0	6%
Accuracy										
Animal sample SD *(sy,x)*	- Total range			10%			20%			25%
	- Low									
	- Medium	0,10	6,0		0,20	12,0		0,25	15,0	
	- High	0,20			0,20 [b]			0,25 [b]		
Calibration [c]										
Mean bias ($\bar{d}$)	- Total range		± 1,2	± 5 %		± 2,4	± 10 %		± 3,0	± 13 %
	- Medium	±0,05			±0,10			±0,13		
	- High	±0,10			±0,20			±0,25		
Slope *(b)*		1±0,05	1±0,10	1±0,05	1±0,10	1±0,10	1±0,10	1±0,13	1±0,10	1±0,13

EXISTING

NEW (x2)

NEW (x2,5)

[a] Where relevant i.e. for in-line differed time analysis.
[b] No larger tolerance by the usual factor 2 for sheep and goat to maintain accuracy with no more numerous records.
[c] Compared to manufacturer calibration.

CONCLUSION

1 - Accuracy limits for on-farm analysis are proposed in a way to measure significant events compared to natural day-to-day variation ; **Fat is used a the basis of the model with a limit of 95% variation of ±0,5 g/100g**

2 - More frequent sampling and analysis allow lower measurement accuracy (including sampling and analysis) to achieve a same precision of production estimate ; **equivalence is achieved with 1,5 time more measurements**.

3- Accuracy limits for fat define a ratio of accuracy vs lab analysers, the **equivalence factor FE - applicable to other components** to establish an overall congruence for genetic evaluation precision.

4- It is proposed to distinguish 3 categories of analysers related to accuracy and depending on FE : 1- Laboratory analysers, 2- On-farm/at-line analysers, 3- On-farm/in-line analysers

Thus congruence can be maintained and homogeneous ways of life (guidelines) applied, provided special adaptation/attention for in-line real time analytical devices.

… still on-going work !

THANK YOU FOR YOUR ATTENTION !