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sensors
MDPI

Cow Milk Quality Determination Using Near-infrared Spectroscopic Sensing System for Smart Dairy Farming

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Dairy farming

Feeding

Manure treatment

Labour intensive

Milking

Livestock management

Herd management

Extensive dairy farmers manage their livestock in groups

Individual cow management

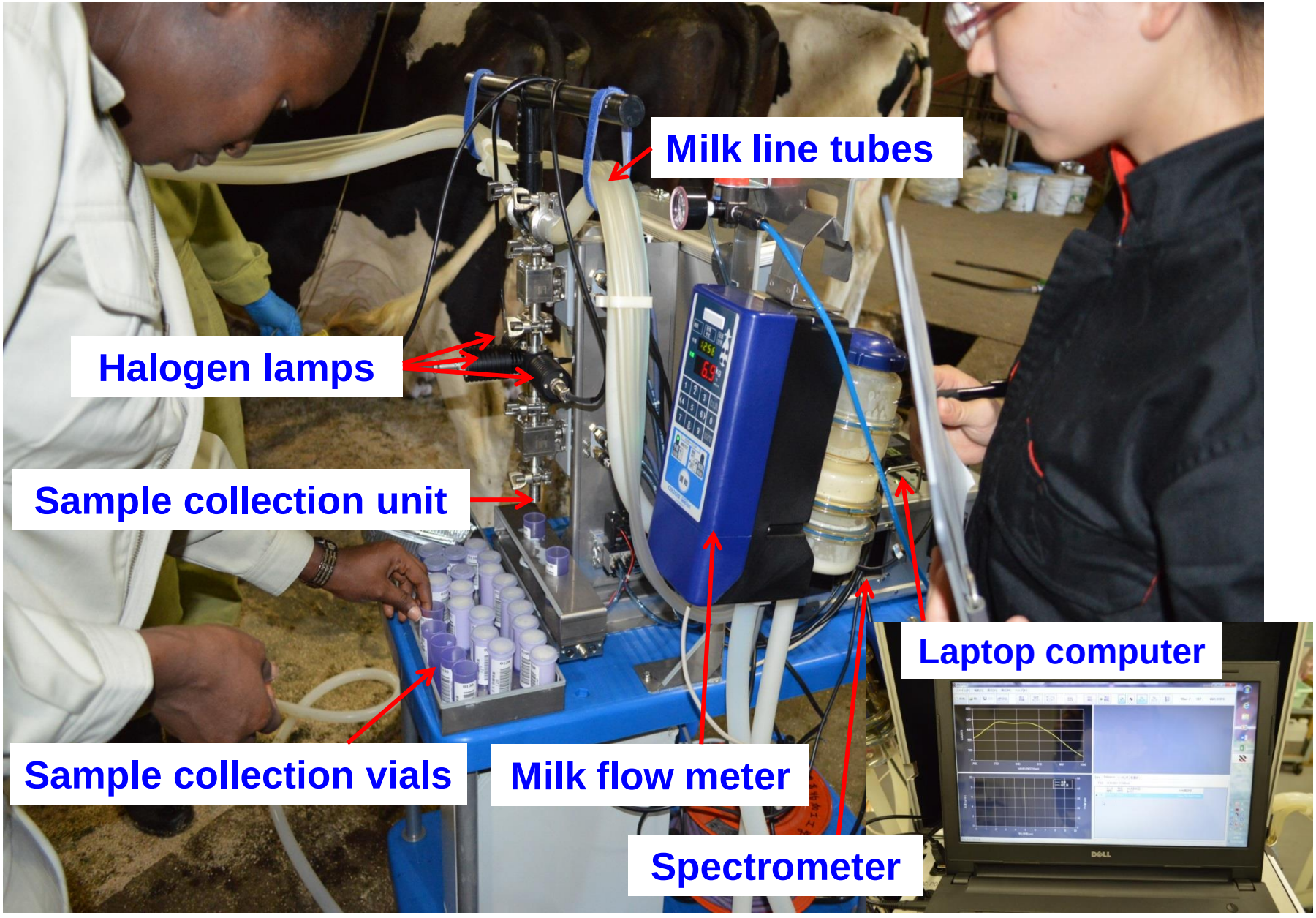
Monitoring the information of each cow is necessary for the production of high-quality milk

Dairy farmers have very strong need for a system to measure milk quality of individual cow during milking

Develop..

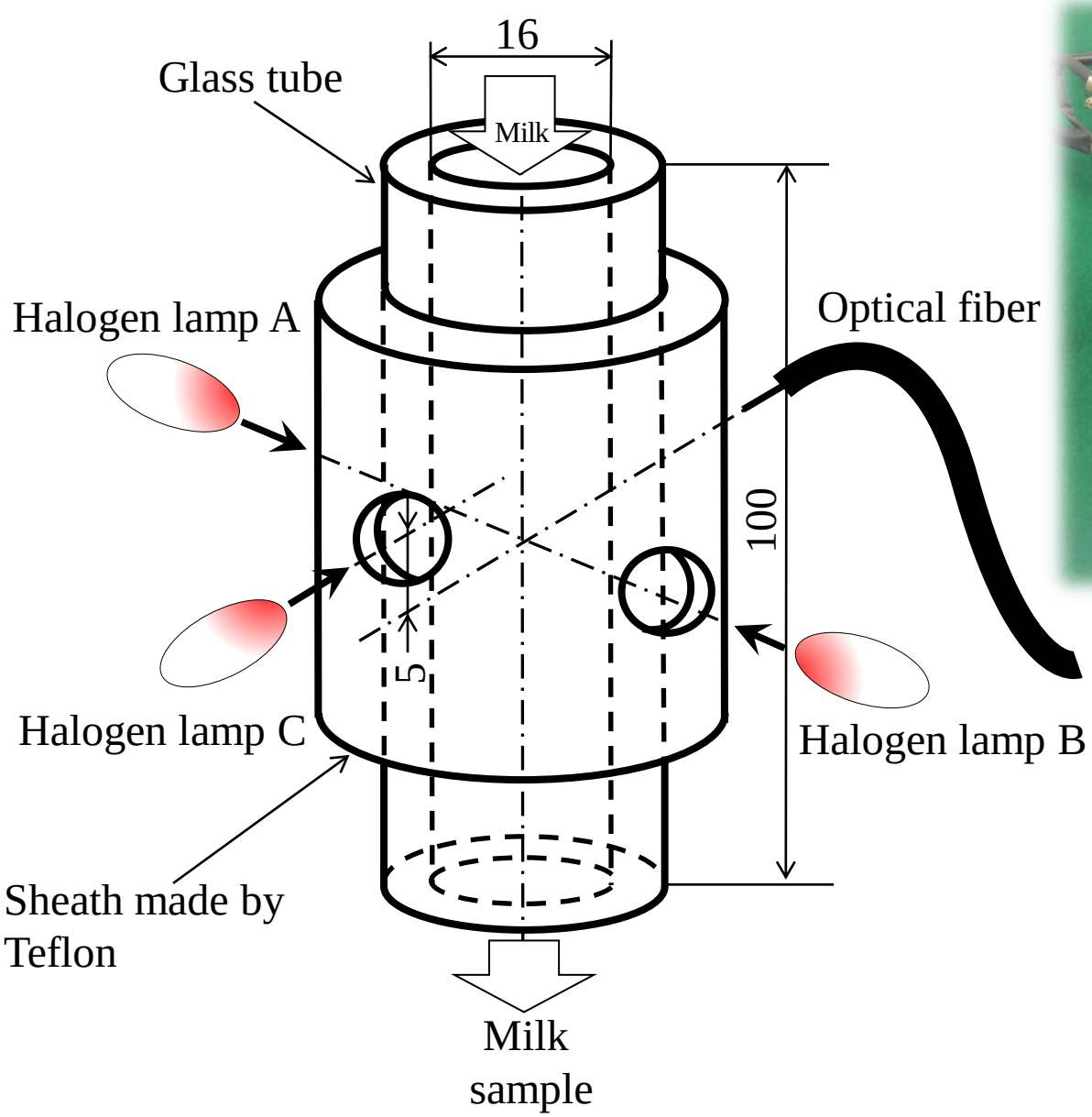
Novel near-infrared spectroscopic sensing system for milk quality determination during milking

Test Equipment



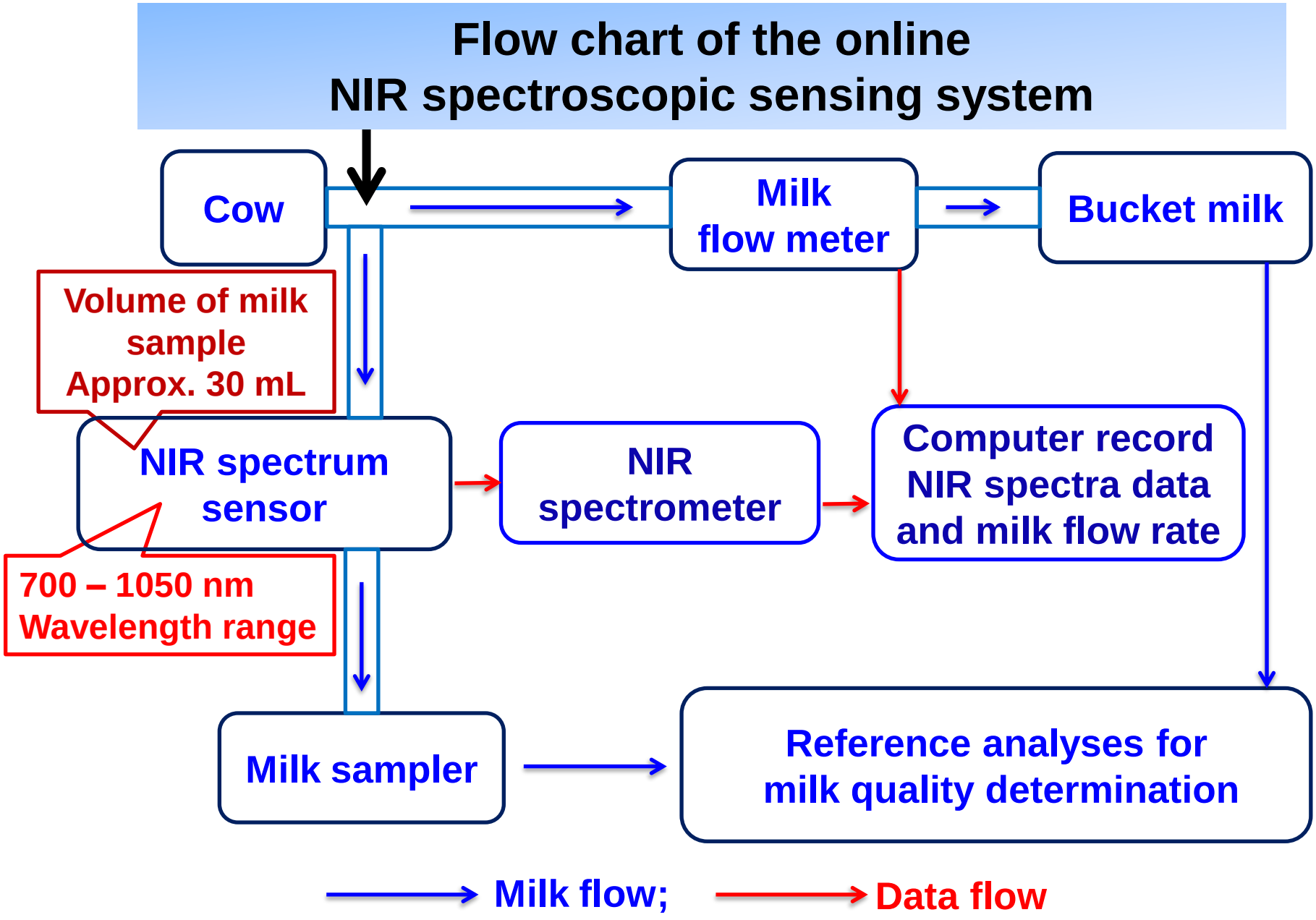
Online real-time near-infrared spectroscopic sensing system

Schematic diagram of the optical system



Original NIR Sensor

Spectrum sensor
Milk chamber
Three halogen lamps
Optical fiber


Flow chart of the online
NIR spectroscopic sensing system
Cow
Milk
flow meter
Bucket milk
Volume of milk
sample
Approx. 30 mL
NIR spectrum
sensor
NIR
spectrometer
Computer record
NIR spectra data
and milk flow rate
700 – 1050 nm
Wavelength range
Milk sampler
Reference analyses for
milk quality determination
Milk flow;
Data flow

Methodology: Milking Mechanism

- Fat（%）
- Protein（%
- Lactose（%）

Milk quality indicators

- Milk urea nitrogen (MUN) (mg/dL)

Protein feeding efficiency indicator

- Somatic cell count (SCC)（log SCC/mL）

⬇

Milk quality
and health status indicator

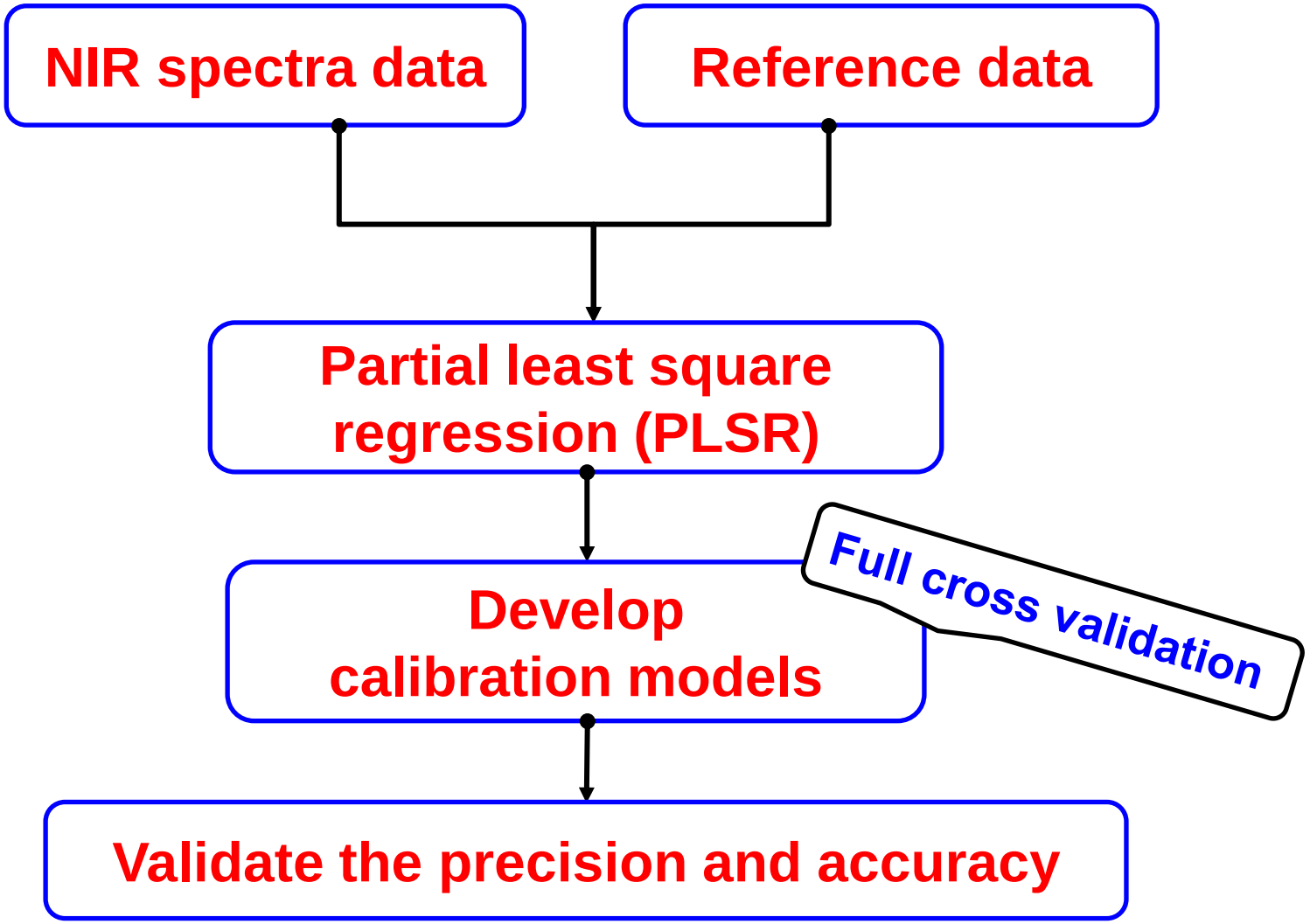
Reference analyses

- **Milkoscan instrument was used to measure milk fat, protein, lactose, and SNF**
- **Fossomatic instrument was used to measure the somatic cell count (SCC) of the raw milk of 2 Holstein cows**

Reference analysis was carried out by Hokkaido Dairy Milk Recording and Testing Association

Chemometric analyses

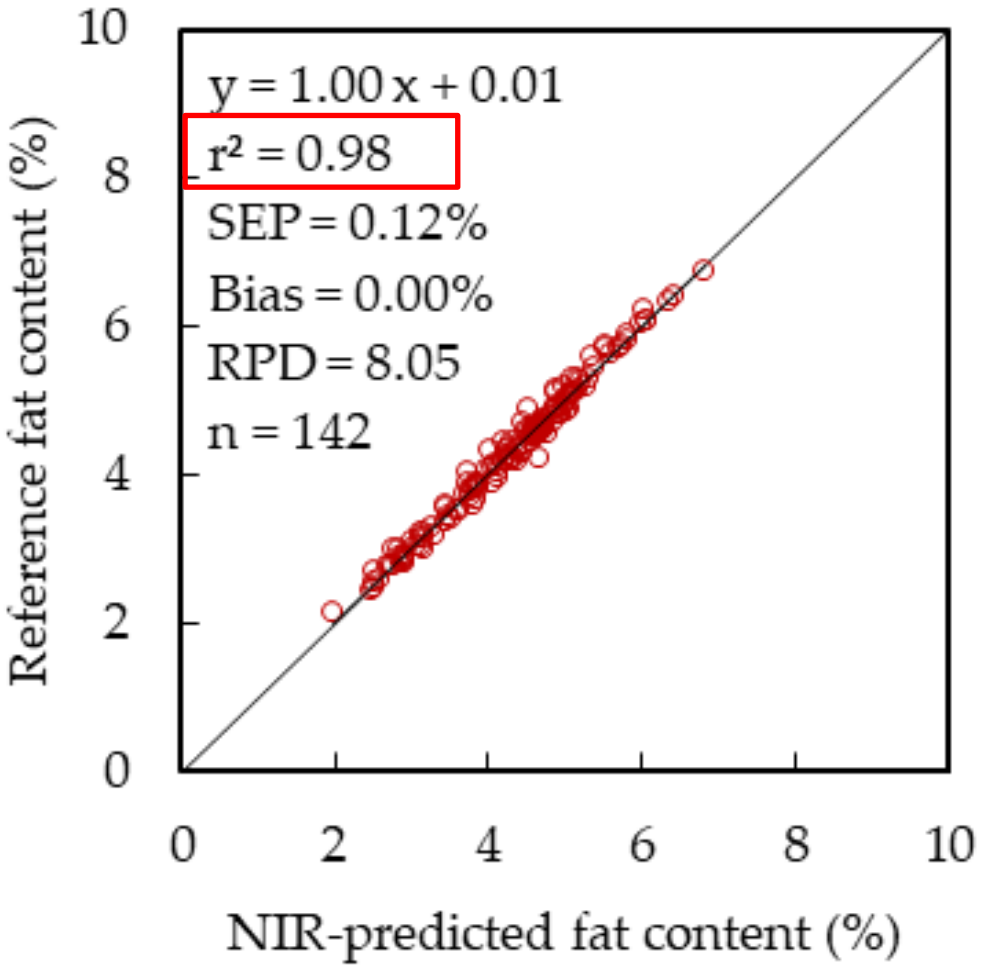
All samples data set was used to develop calibration models



Validation statistics of NIRS sensing system for the determination of cow milk quality

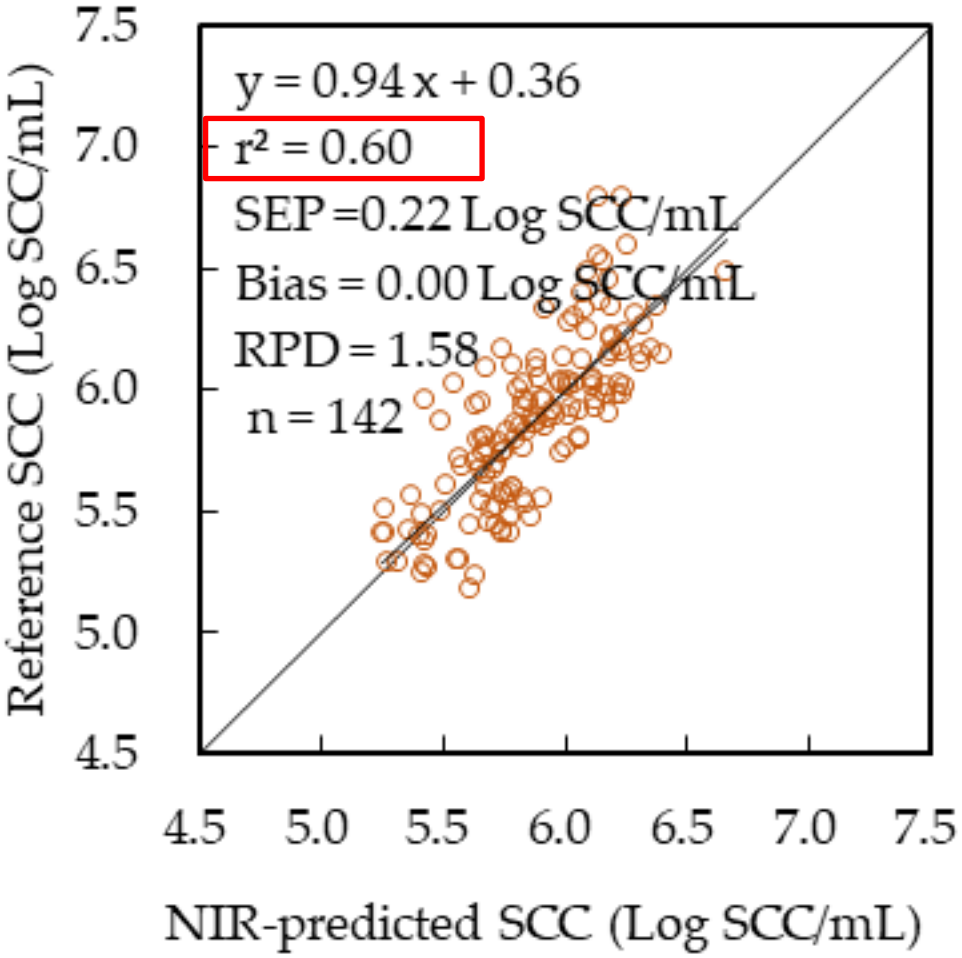
Milk quality indicators	n	Range	R^2	SEP	Bias	RPD
fat (%)	142	2.1-6.8	0.98	0.12	0.00	8.05
Protein (%)	142	3.3-3.8	0.92	0.03	0.00	3.58
Lactose (%)	142	3.9-4.7	0.70	0.09	0.00	1.83
MUN (mg/dL)	142	8.9-13.8	0.45	0.60	0.10	1.35
SCC (log SCC/mL)	142	5.2-6.8	0.60	0.22	0.00	1.58

High and sufficient levels of precision and accuracy



Monitoring of milk constituents during milking

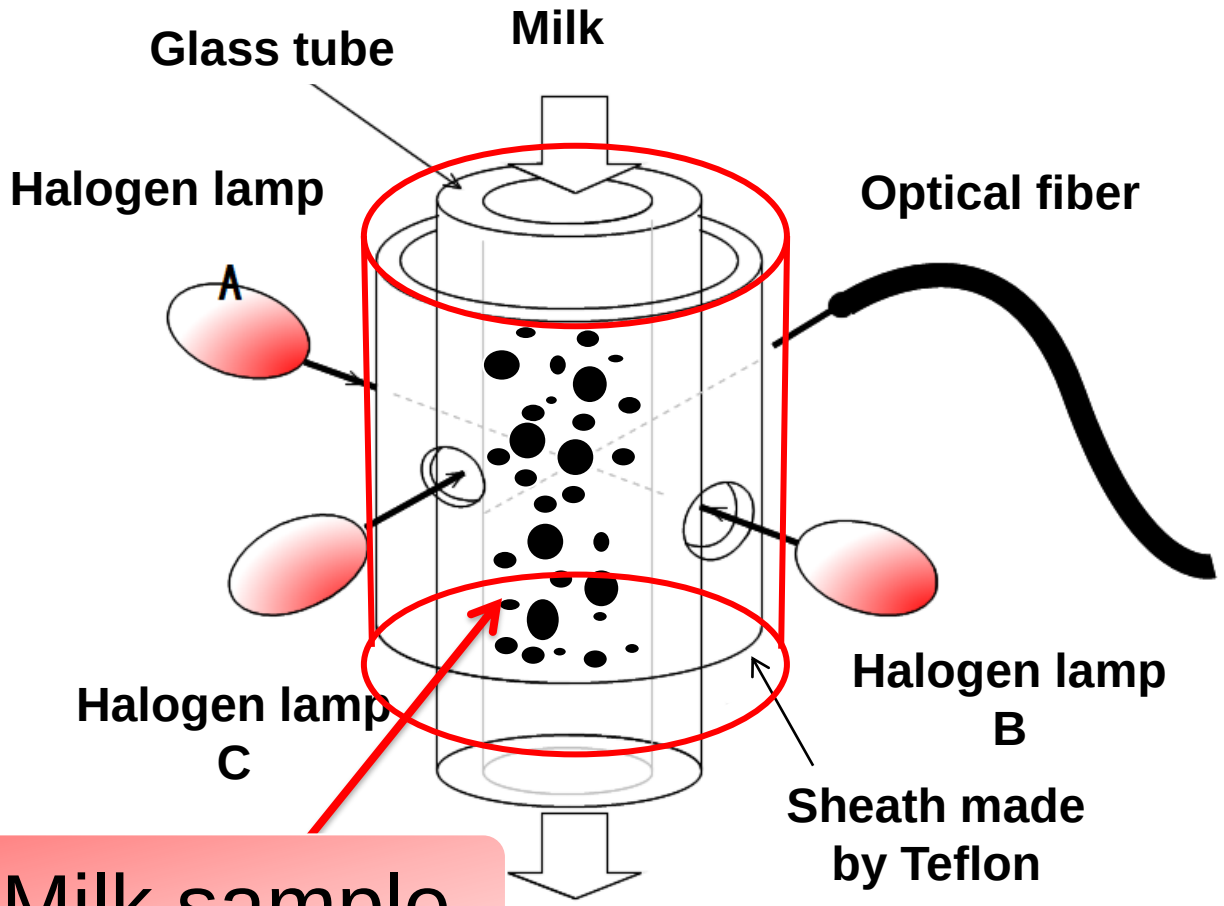
The accuracy of the NIR spectroscopic sensing system used in this study was very high



Diagnosis of subclinical mastitis

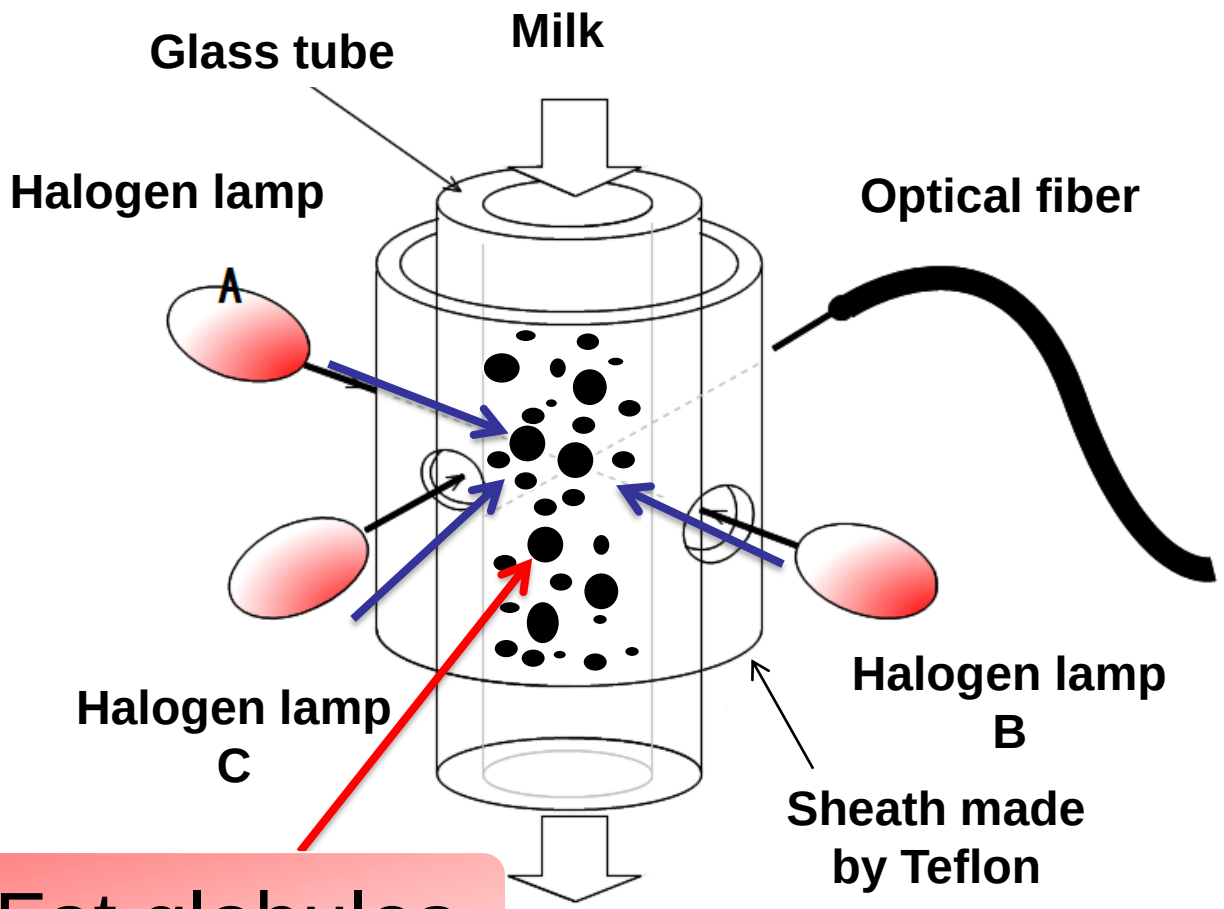
The precision and accuracy for predicting somatic cell count (SCC) was sufficient

Cylindrical structure of NIR spectrum sensor



Reduce the effect of air bubbles and fluctuation in milk flow

NIR spectrum sensor



NIR sensor accurately captured NIR light most especially by fat content

The precision and accuracy for determining milk fat, protein, lactose, MUN, and SCC was sufficiently high

Reasons

NIR spectroscopic sensing system:

- Cylindrical structure of the NIR sensing system
- Three halogen lamps were used
- Exposure time (200 msec)
- Increased repetition times (10 times)

Reduced spectra noise

NIR sensing system developed could be used for on-line real-time measurement of

fat, protein, lactose, MUN, and SCC during milking with sufficient precision and accuracy

- Meet the requirement of dairy farmers and veterinarians

- **Rapid** feedback control for upgrading dairy farm **(individual cow)** management

- Relieve dairy farmers of poor cow milk production and economic losses

- **Application of NIR sensing system**

Dairy precision farming

Further studies..

Practical application of
NIR sensing system to determine the milk quality of individual cow during milking

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