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Use of mid-infrared spectroscopy to predict coagulation properties of buffalo milk

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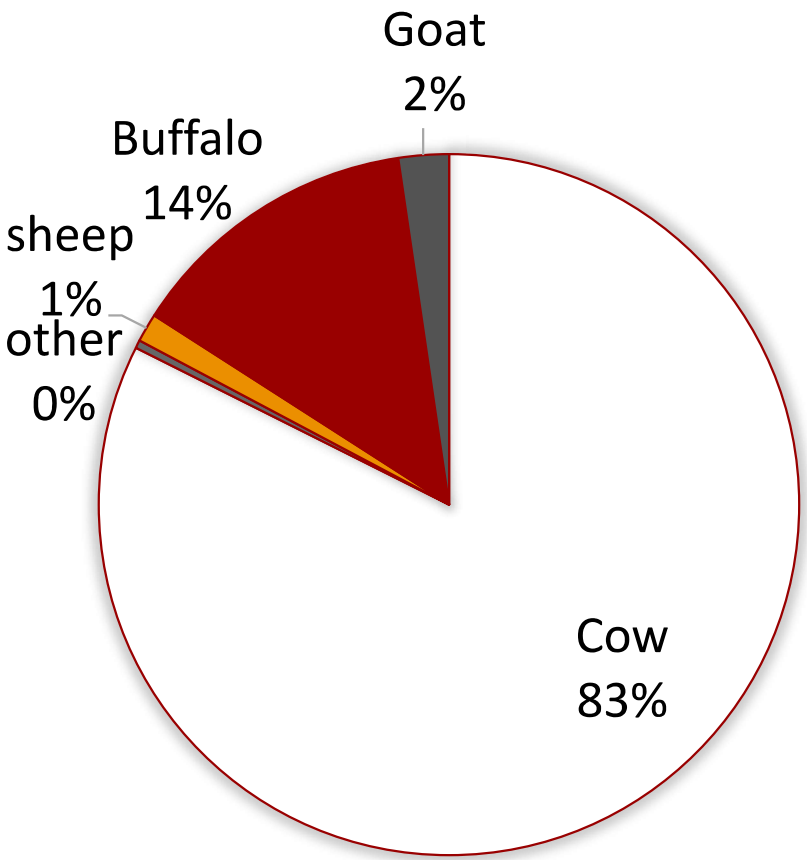
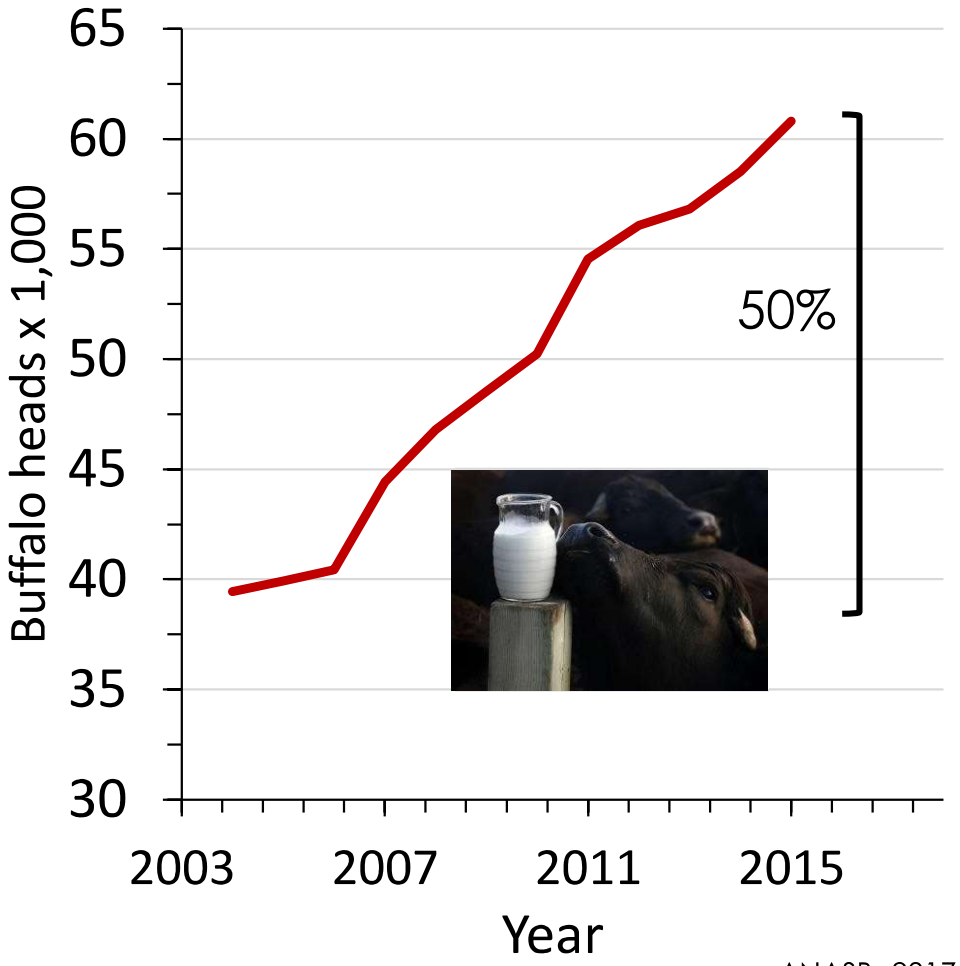
Introduction

World Milk Production



FAOSTAT,2017

Italian Buffalo Census



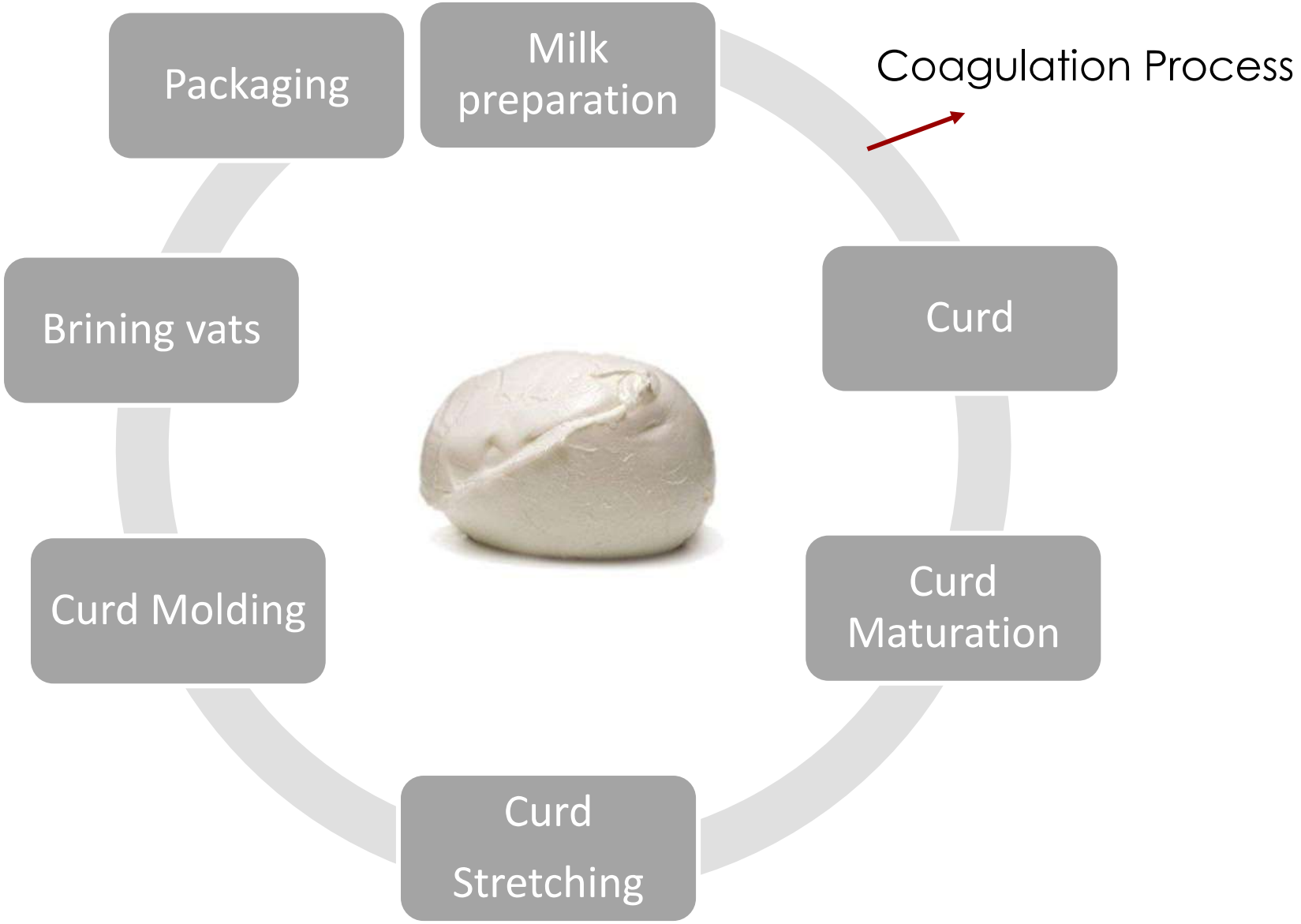
ANASB, 2017

Buffalo Milk

Milk yield and composition	
Milk yield (kg/d)	7.11
Fat (%)	7.70
Protein (%)	4.76
Casein (%)	3.65
Lactose (%)	4.60

Manuelian et al., 2017

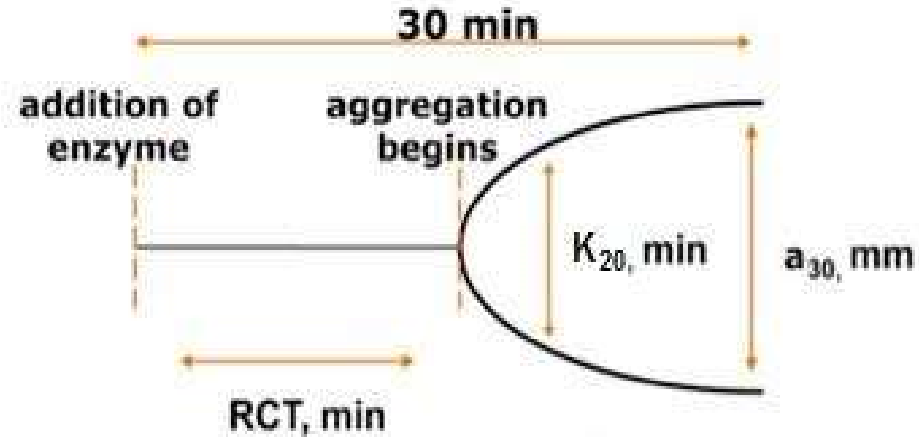
Mozzarella cheese making process



Milk Coagulation Properties (MCP)

- **RCT** = rennet coagulation time, min
- $\mathbf{k_{20}}$ = curd-firming time, min
- $\mathbf{a_{30}}$ = curd firmness after 30 min from rennet addition, mm

Formagraph, FOSS Electric A/S

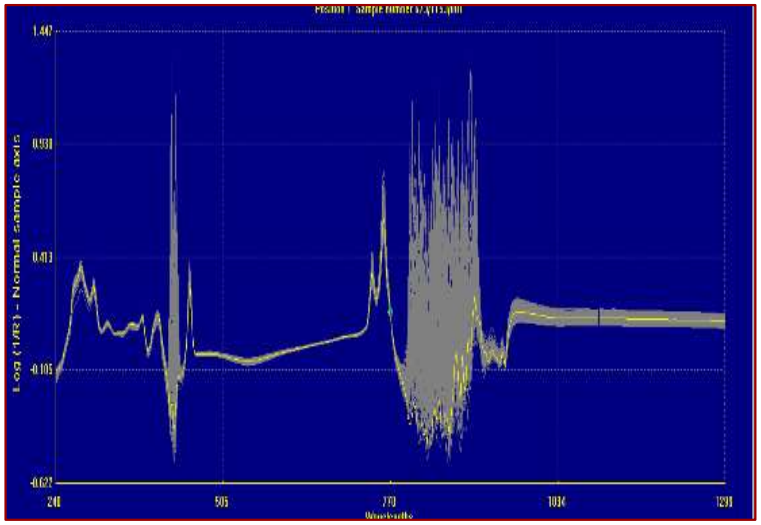


Output of Formagraph

Mid-infrared spectroscopy (MIRS) analysis

- Cheap
- Chemical-free
- No time-consuming
- 500 samples/hour
- Routine determination of milk composition traits

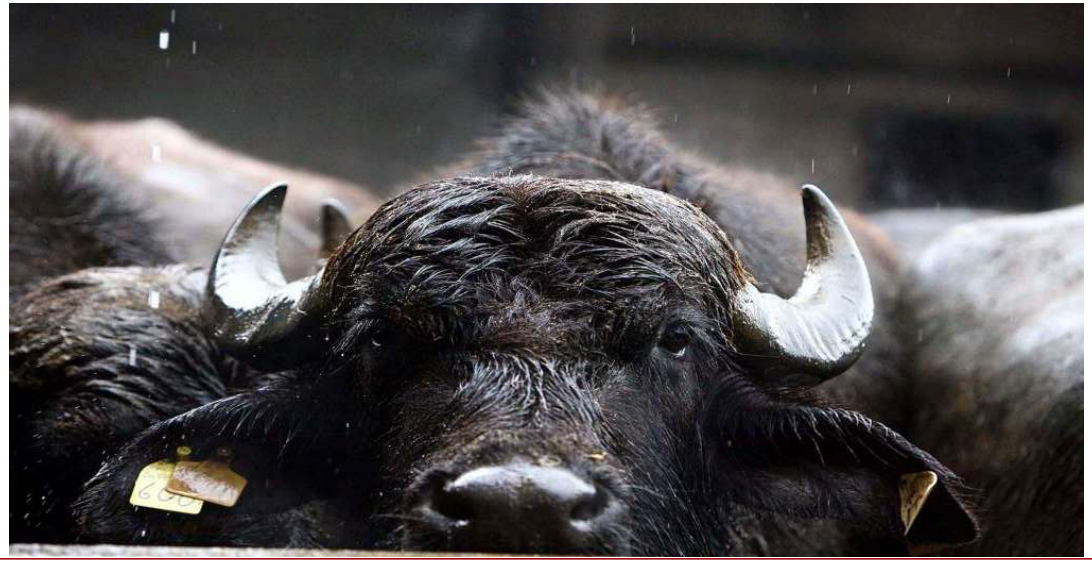
Milkoscan FT6000, FOSS Electric A/S



MIRS spectra

AIM

To investigate the feasibility of MIRS to predict MCP of buffalo milk



Material and Methods

Buffalo milk

116 samples (50 ml)
Bronopol (preservative)
Collected in March 2017 from 2 farms of North Italy (Veneto)

Formagraph, Foss

MilkoScan FT 6000, Foss

Match of reference data and spectra

MCP prediction equations

Mid-infrared spectroscopy (MIRS) analysis

- Software: WinISI III v 1.60
- Spectra region from 5,000 to 900 cm^{-1}
- Removal of water noise regions (3,690 to 2,990 cm^{-1} and 1,710 to 1,580 cm^{-1})
- Modified partial least squares regression analysis
- Several math treatments (25 combinations)

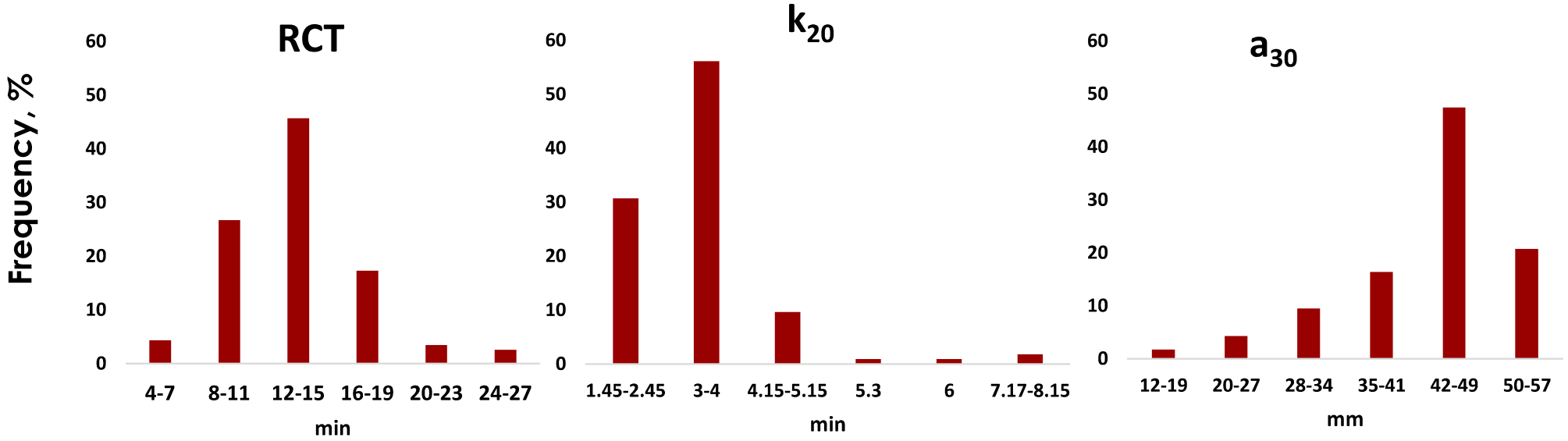
Prediction procedures

- Cross-validation (116 samples)
- External-validation (75% of samples for calibration set and 25% for validation set)

Results

Trait	N	Mean	Min	Max	SD
RCT, min	116	13.07	4.00	26.3	3.86
k_{20}, min	114	3.19	1.45	8.15	0.99
a_{30}, mm	116	43.88	12.88	56.24	8.32

RCT = rennet coagulation time; k_{20} = curd-firming time; a_{30} = curd firmness 30 min after rennet addition to milk



Fitting statistics of prediction models

Cross-validation								
Trait	N	Mean	SD	SE_C	R^2_C	SE_{CV}	R^2_{CV}	RPD_{CV}
RCT, min	110	12.99	3.56	1.55	0.81	1.89	0.72	1.88
k_{20}, min	103	3.02	0.63	0.46	0.47	0.47	0.44	1.34
a_{30}, mm	113	44.53	7.25	3.84	0.72	4.92	0.54	1.47

External-validation							
	Calibration set (n=87)			Validation set (n=29)			
Trait	Mean	SD	R^2c	Mean	SD	R^2_{Exv}	RPD_{Exv}
RCT, min	13.06	3.77	0.76	12.85	3.29	0.49	1.28
k_{20}, min	2.97	0.64	0.58	3.00	0.58	0.27	1.18
a_{30}, mm	45.20	7.04	0.66	43.87	7.15	0.54	1.48

RCT = rennet coagulation time; k_{20} = curd-firming time; a_{30} = curd firmness 30 min after rennet addition to milk R^2c= coefficient of determination of calibration; SE_{CV} = standard error in cross-validation; R^2_{cv} = coefficient of determination of cross-validation; RPD_{cv} = residual predictive deviation of cross-validation calculated as the ratio of SD to the SE_{cv}.

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Conclusions

- Prediction models not enough accurate to be implemented in milk payment systems.
- Prediction models allow milk segregation.
- Future studies will investigate the feasibility of using MIRS predictions as indicator traits in breeding programs for the enhancement of coagulation properties of buffalo milk.

Thank you for your attention