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Session n. 33
Mediterranean buffalo farming for sustainable milk and meat production

Reggiana – Palazzo Affari, 2nd Floor

Feasibility of visible/near-infrared spectroscopy to predict the chemical composition of feces and total-tract apparent nutrients digestibility in lactating buffaloes

Guerra[1], A., Simoni[2], M., Longobardi[3], V., Goi[1], A., Mantovani[2], G., Danese[2], T., Neglia[3], G., De Marchi[1], M., Righi[2] F.

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- The interest in Mediterranean buffalo farming is increasing worldwide and, over the last 20 years, much effort has been focused on increasing the milk yield in Italy.

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Milk somatic cell count and its relationship with milk yield and quality traits in Italian water buffaloes

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Animal Science Journal
Animal Science Journal (2018) 89, 176–185 doi:10.1111/asj.12916

ORIGINAL ARTICLE

Trends in the quality and hygiene parameters of bulk Italian Mediterranean buffalo (*Bubalus bubalis*) milk: A three year study

Marina PASQUINI, Andrea OSIMANI, Stefano TAVOLETTI, Itzhak MORENO, Francesca CLEMENTI and Maria Federica TROMBETTA

Heat stress alleviation in lactating buffaloes: Effect on physiological response, metabolic hormone, milk production and composition

K S DAS[1], J K SINGH[2], G SINGH[3], R C UPADHYAY[4], R MALIK[5] and P S OBEROI[6]

- This specie is particularly interesting for its unique milk quality, and most of the scientific literature focuses on milk and cheese production and characteristics while less studied is nutrient digestibility which is important in determining diet and livestock efficiency.

1. INTRODUCTION

Study of digestibility

Gold Standar
Total fecal collection

Using of marker

Near Infrared Spectroscopy

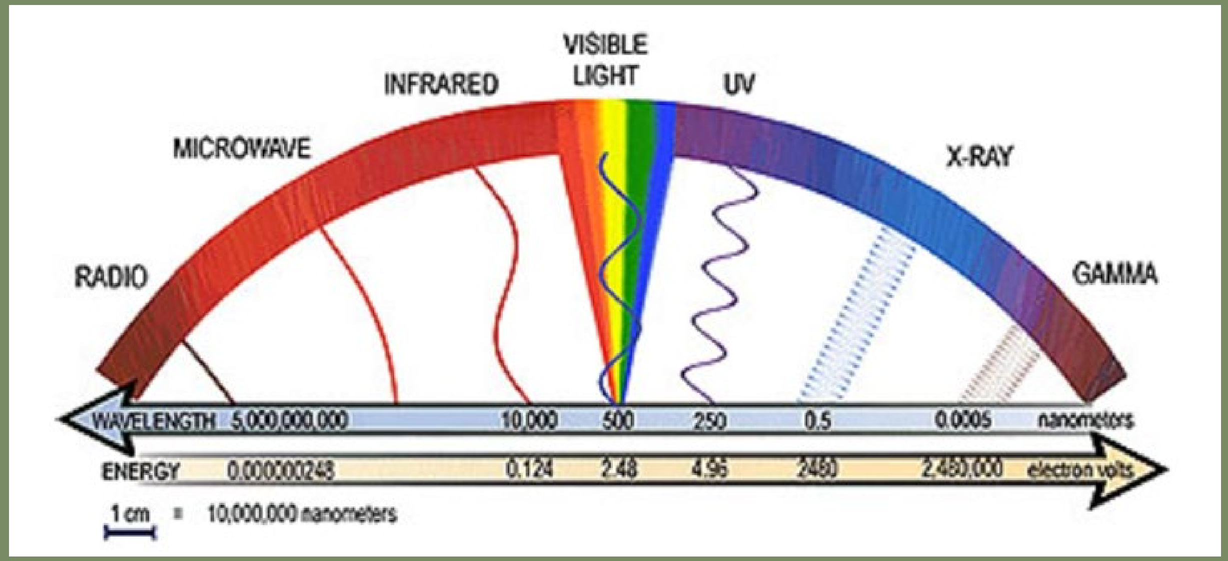
Nutrient total-tract digestibility is one of the traits that allows for the assessment of energy value of feed and feed efficiency

Total tract nutrient digestibility (TTND)

Apparent Total Tract Nutrient Digestibility (ATTND)

The study of animal fecal matter has long been recognized as a valuable means to assess diet utilization and animal health. Despite the accuracy and precision, nutritional analysis like digestibility are **expensive** and **time consuming.**

Near-Infrared Spectroscopy (NIRS) is an analytical technique used to determine the chemical composition of various materials. It uses near-infrared light to analyze samples and provide rapid, non-destructive information about their composition, such as moisture, protein, fat, and other nutrients.



Near-Infrared Spectroscopy (NIRS) is used in various fields due to its ability to provide **quick and non-destructive analysis** of the chemical composition of materials.

Agriculture: NIRS is used to assess the quality of crops, soil, and animal feed by determining moisture, protein, fiber, and other nutrient contents.

Food Industry: It is used for quality control and assurance, including the analysis of dairy products, meat, beverages, and grains, to ensure consistency and safety.

Environmental Science: NIRS is used to analyze soil and water samples for pollution monitoring and management.

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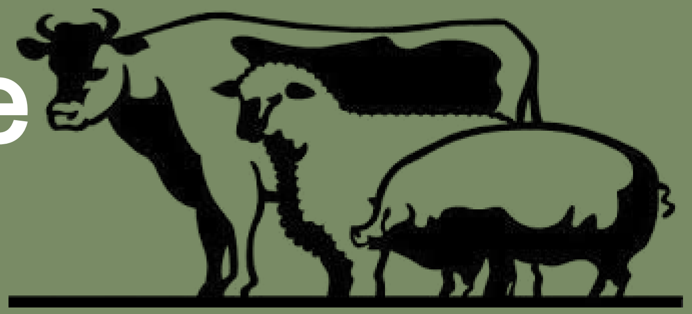
Animal Science



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Compare estimates of apparent/total tract nutrient digestibility in lactating buffaloes using single-point NDF or AIA as internal markers.

Explore the potential of fecal NIRS to provide calibration equations for assessing the chemical composition and total nutrient digestibility traits estimated with internal markers.

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Experimental design

147 individual fresh fecal sample
were obtained from lactating buffaloes

5 different farms located in the area of Mozzarella Bufala Campana PDO

TMR feed was sampled in each farm during feed delivery

- ✓ Both TMR and fecal samples were oven dried at 55°C to constant weight and then ground in a Retch SK mill to pass a 1-mm screen.

Fecal Sample

TMR Sample

Chemical analyses at the Laboratory of Feed Analysis of the Department of Veterinary Science of the University of Parma (Parma, Italy)

Fecal Sample

Near-infrared spectra of each samples were obtained using DS2500, located at the DAFNAE department (University of Padova, Legnaro, Italy)

Average chemical composition of the TMR feed to the lactating buffaloes

TRAIT	MEAN	SD
DM, %as fed	44.3	7.7
OM, %DM	92.4	1.2
Ash, %DM	8.0	1.2
EE, %DM	5.2	2.0
aNDF, %DM	44.7	4.3
ADF, %DM	26.2	1.2
Lignin, %DM	4.8	0.6
HC, %DM	16.7	3.4
CEL, %DM	21.4	1.2
N, %DM	2.3	0.1
CP, %DM	14.5	1.0
Starch, %DM	21.7	3.1
AIA, %DM	1.8	0.3
uNDF, %DM	14.7	1.5

A silage based TMR their dietary formulations, having a forage to concentrate ratio ranging from 25:75 to 52:48. All diets, were based on corn silage, alfalfa hay and haylage, mixed hay, concentrates and a mineral- vitamin supplementation.

Total-tract digestibility

$$DM\ Intake\ (Kg) * uNDFdiet\ (\%) = DM\ Fecal\ escretion\ (Kg) * uNDFfeces(\%)$$

$$100 - uNDFdiet\ (\%) / uNDFfeces(\%) = \boldsymbol{tt(a)NDFD}$$

Fustini et al., 2017

Statistical analyses

Dried and ground faeces samples

75% calibration set

25% validation set

Sample stratified 5-fold cross validation

Final model

Model performance

- ✓ Prediction models were developed using (mPLS) modified partial least squares regression analysis.
- ✓ Each model was built using faeces spectra against reference analysis.
- ✓ The optimal calibration models were identified based on the number of latent factors selected to minimize the RMSE of external-validation, SE_{ExV}, R^2_{ExV}, and RPD_{ExV}.

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Average chemical composition of the feces collected from the lactating buffaloes

TRAITS	MEAN	SD
DM, %as fed	93.4	0.7
OM, %DM	84.5	2.9
Ash, %DM	15.4	2.7
EE, %DM	1.9	0.5
aNDFom, %DM	57.5	4.7
aNDF, %DM	62.1	4.7
ADF, %DM	39.9	3.4
Lignin, %DM	9.8	1.5
HC, %DM	24.2	3.7
CEL, %DM	27.9	3.8
N, %DM	2.3	0.2
CP, %DM	14.2	1.3
Starch, %DM	1.7	0.6
AIA, %DM	6.1	1.0
uNDF, %DM	41.4	5.7

Prediction models in external validation for chemical composition of feces (n = 36)

TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
Ash, %DM	1.40	0.70	0.04	0.76	1.66
EE, %DM	0.27	0.72	-0.05	1.02	1.89
aNDFom, %DM	2.31	0.72	0.41	1.05	1.89
aNDF, %DM	1.86	0.77	0.18	1.03	2.12
ADF, %DM	2.19	0.66	2.19	0.68	1.43
N, %DM	0.10	0.76	0.01	1.06	2.06
CP, %DM	0.56	0.83	0.08	1.15	2.32
AIA, %DM	0.72	0.60	-0.02	1.08	1.60
uNDF, %DM	4.01	0.48	0.67	0.94	1.39

- ✓ $0.50 < R^2_{ExV} < 0.66$, DM, % of pre-dried sample; OM, %DM; ADFom, %DM.
- ✓ $R^2_{ExV} < 0.50$, ADL, %DM; HC, %DM; CEL, %DM; NDIN, %DM; ADIN, %DM; NB3, %DM; NFC, %DM and Starch, %DM.

Prediction models in external validation for chemical composition of feces (n = 36)

TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
Ash, %DM	1.40	0.70	0.04	0.76	1.66
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aNDFom, %DM	2.31	0.72	0.41	1.05	1.89
aNDF, %DM	1.86	0.77	0.18	1.03	2.12
ADF, %DM	2.19	0.66	2.19	0.68	1.43
N, %DM	0.10	0.76	0.01	1.06	2.06
CP, %DM	0.56	0.83	0.08	1.15	2.32
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- ✓ $R^2_{ExV} < 0.50$, ADL, %DM; HC, %DM; CEL, %DM; NDIN, %DM; ADIN, %DM; NB3, %DM; NFC, %DM and Starch, %DM.

4. RESULTS & DISCUSSIONS

Descriptive statistics of average total-tract apparent (tta) and total-tract true (tt) nutrients digestibility estimated (De) using fecal uNDF and AIA as a marker of feces of lactating buffaloes

uNDFmarker

TRAITS	MEAN	SD
ttaDMDe	64.65	3.60
ttaOMDe	67.63	3.42
ttAshDe	32.38	13.41
ttaEEDe	84.67	8.57
ttaNDFDe	50.22	5.64
ttADFDe	46.23	7.21
ttHCDe	48.37	10.95
ttCELDe	53.90	8.38
ttaNDe	65.52	5.28
ttaCPDe	65.52	5.28
ttaStarchDe	97.30	1.04

AIA marker

TRAITS	MEAN	SD
ttaDMDe	69.57	4.14
ttaOMDe	72.04	4.05
ttAshDe	39.67	11.95
ttaEEDe	86.25	8.82
ttaNDFDe	56.56	7.84
ttADFDe	53.53	6.58
ttHCDe	54.16	13.31
ttCELDe	60.21	7.27
ttaNDe	70.12	5.41
ttaCPDe	70.12	5.41
ttaStarchDe	97.70	0.90

Descriptive statistics of average total-tract apparent (tta) and total-tract true (tt) nutrients digestibility estimated (De) using fecal uNDF and AIA as a marker of feces of lactating buffaloes

uNDF marker

TRAITS	MEAN	SD
ttaDMDe	64.65	3.60
ttaOMDe	67.63	3.42
ttAshDe	32.38	13.41
ttaEEDe	84.67	8.57
ttaNDFDe	50.22	5.64
ttADFDe	46.23	7.21
ttHCDe	48.37	10.95
ttCELDe	53.90	8.38
ttaNDe	65.52	5.28
ttaCPDe	65.52	5.28
ttaStarchDe	97.30	1.04

uNDF < AIA

AIA marker

TRAITS	MEAN	SD
ttaDMDe	69.57	4.14
ttaOMDe	72.04	4.05
ttAshDe	39.67	11.95
ttaEEDe	86.25	8.82
ttaNDFDe	56.56	7.84
ttADFDe	53.53	6.58
ttHCDe	54.16	13.31
ttCELDe	60.21	7.27
ttaNDe	70.12	5.41
ttaCPDe	70.12	5.41
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ttaNDFDe	50.22	5.64
ttADFDe	46.23	7.21
ttHCDe	48.37	10.95
ttCELDe	53.90	8.38
ttaNDe	65.52	5.28
ttaCPDe	65.52	5.28
ttaStarchDe	97.30	1.04

AIA marker

TRAITS	MEAN	SD
ttaDMDe	69.57	4.14
ttaOMDe	72.04	4.05
ttAshDe	39.67	11.95
ttaEEDe	86.25	8.82
ttaNDFDe	56.56	7.84
ttADFDe	53.53	6.58
ttHCDe	54.16	13.31
ttCELDe	60.21	7.27
ttaNDe	70.12	5.41
ttaCPDe	70.12	5.41
ttaStarchDe	97.70	0.90

4. RESULTS & DISCUSSIONS

Prediction models in external validation for total-tract apparent (tta) or true (tt) nutrients digestibility estimated (De) using fecal uNDF as a marker of feces (n = 36)

uNDF marker

TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
ttAshDe	8.58	0.58	0.05	0.93	1.53
ttaEEDe	3.34	0.89	-0.93	1.14	2.78
ttADFomDe	5.73	0.55	-0.33	0.83	1.47
ttNDINDe	9.13	0.74	0.19	0.94	1.96
ttADINDe	8.64	0.90	0.31	0.91	3.16
ttNB3De	12.52	0.61	0.90	0.78	1.53
ttaNFCDe	2.99	0.58	-0.12	0.93	1.56

- ✓ $R^2_{ExV} < 0.50$, ttaDMDe, ttaOMDe, ttaNDFomDe, ttaNDFDe, ttADFDe, ttHCDe, ttCELDe, ttaNDe, ttaCPDe, ttaStarchDe.

Prediction models in external validation for total-tract apparent (tta) or true (tt) nutrients digestibility estimated (De) using fecal uNDF as a marker of feces (n = 36)

uNDF marker

TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
ttAshDe	8.58	0.58	0.05	0.93	1.53
ttaEEDe	3.34	0.89	-0.93	1.14	2.78
ttADFomDe	5.73	0.55	-0.33	0.83	1.47
ttNDINDe	9.13	0.74	0.19	0.94	1.96
ttADINDe	8.64	0.90	0.31	0.91	3.16
ttNB3De	12.52	0.61	0.90	0.78	1.53
ttaNFCDe	2.99	0.58	-0.12	0.93	1.56

✓ $R^2_{ExV} < 0.50$, ttaDMDe, ttaOMDe, ttaNDFomDe, ttaNDFDe, ttADFDe, ttHCDe, ttCELDe, ttaNDe, ttaCPDe, ttaStarchDe.

Prediction models in external validation for total-tract apparent (tta) or true (tt) nutrients digestibility estimated (De) using fecal uNDF as a marker of feces (n = 36)

AIA marker

TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
ttaEEDe	4.68	0.86	-1.13	1.33	2.22
ttADFomDe	7.93	0.54	-0.19	0.56	1.35
ttHCDe	9.77	0.50	-0.75	0.70	1.31
ttNDINDe	13.15	0.62	-0.11	0.99	1.65
ttNB3D	13.72	0.59	-0.16	0.93	1.58

✓ $R^2_{ExV} < 0.50$, ttaDMDe, ttaOMDe, ttAshDe, ttaNDFomDe, ttaNDFDe, ttADFDe, ttCELDe, ttaNDe, ttaCPDe, ttADINDe, ttaNFCD, ttaStarchDe

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TRAITS	SE_{ExV}	R^2_{ExV}	BIAS	SLOPE	RPD_{ExV}
ttaEEDe	4.68	0.86	- 1.13	1.33	2.22
ttADFomDe	7.93	0.54	- 0.19	0.56	1.35
ttHCDe	9.77	0.50	- 0.75	0.70	1.31
ttNDINDe	13.15	0.62	- 0.11	0.99	1.65
ttNB3D	13.72	0.59	- 0.16	0.93	1.58

✓ R^2_{ExV} < 0.50, ttaDMDe, ttaOMDe, ttAshDe, ttaNDFomDe, ttaNDFDe, ttADFDe, ttCELDe, ttaNDe, ttaCPDe, ttADINDe, ttaNFCD, ttaStarchDe

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Conclusion

The NIRS technology efficiently estimate N and consequently CP, EE, Ash, aNDFom and aNDF content of Mediterranean buffalo feces, while failed to estimate other compositional traits.

NIRS can predict ttaEEDe, ttNDIDe, ttADINe when estimated using uNDF. It is unable to predict all the other nutrients digestibilities when estimated using both uNDF or AIA as markers except for ttaEEDe.

Many traits have margins to improve prediction performance, for uNDF marker: ttAshDe, ttADFomDe, ttNB3De and ttaNFCDe; for AIA marker: ttADFomDe, ttHCDe, ttNDINDe and ttNB3D.

THANK YOU FOR YOUR ATTENTION

Effectiveness of near-infrared spectroscopy to predict the chemical composition of feces and total-tract apparent nutrients digestibility estimated with undigestible neutral detergent fiber or acid-insoluble ash in lactating buffaloes' feces

A. Guerra [1], M. Simoni [2], V. Longobardi [3], A. Goi [1], G. Mantovani [2], T. Danese [2], G. Neglia [3], M. De Marchi [1], F. Righi [2]

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