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THE ROLE OF COLOUR INDEXES FOR THE ASSESSMENT OF SPECIES-SPECIFIC DIFFERENCES IN QUALITY TRAITS OF MILK FROM DOMESTIC RUMINANTS

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PERSONNEL

Meet the **research team**

A quick glance at some of the people involved in this research line

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EAAP
European Federation of Animal Science

INTRODUCTION

Technological aptitude of milk

The cheese sector demands the development of rapid and low-cost methods to determine milk efficiency.

GAPS OF KNOWLEDGE

TECHNOLOGICAL PERFORMANCE OF MILK

INDUSTRY CHALLENGES

ECONOMIC VALUE OF MILK

RESEARCH OPPORTUNITIES

RAPID AND INEXPENSIVE ANALYTIC METHODS

Colour in the food industry

Colour has been traditionally used to characterize the composition and quality of food products.

The colour of milk can vary greatly and depends to a large extent on its physical structure, the fat content and the pigmentation due to the presence of carotenoids and riboflavins.

1. Variation of **colloidal particles**.
2. Effect of **nutrition** in grazing herds.
3. Herd **health and management** practices.

OUR PROPOSED LINE OF RESEARCH

- To explore if colour can be adopted as a tool to <u>predict technological quality</u> of ruminant milk intended for cheesemaking.
- To assess if colour can be <u>used as a discriminator</u>, not only at a species level, but also at a breed level.

Background investigation

What have we achieved so far with this research line?

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Using multivariate analysis to explore the relationships between color, composition, hygienic quality, and coagulation of milk from Manchega sheep

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VERY GOOD PREDICTOR FOR COAGULATION

NON-COAGULATING MILK ⟶ FALSE NEGATIVES (23-33%)

METHODOLOGY

METHODOLOGY

Sample collection

Milk samples (n = 2400) were collected from dairy farms located in Spain and Ireland in the last 10 years.

Milk composition and SCC

Milk composition was performed by direct measurement of the percentage of its major components using a MilkoscanTM *FT-120*, and Somatic Cell Count was measured with a FossomaticTM *Minor Cell Counter*.

MILKOSCANTM *FT-120*

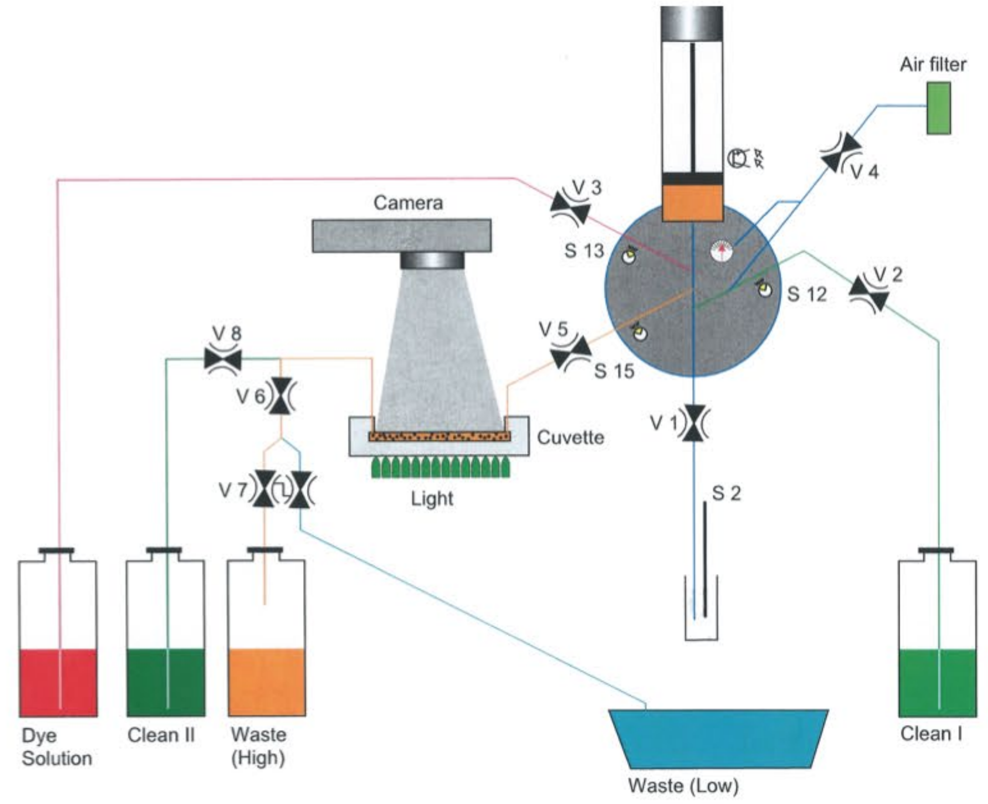
FAT

PROTEIN

LACTOSE

TOTAL SOLIDS

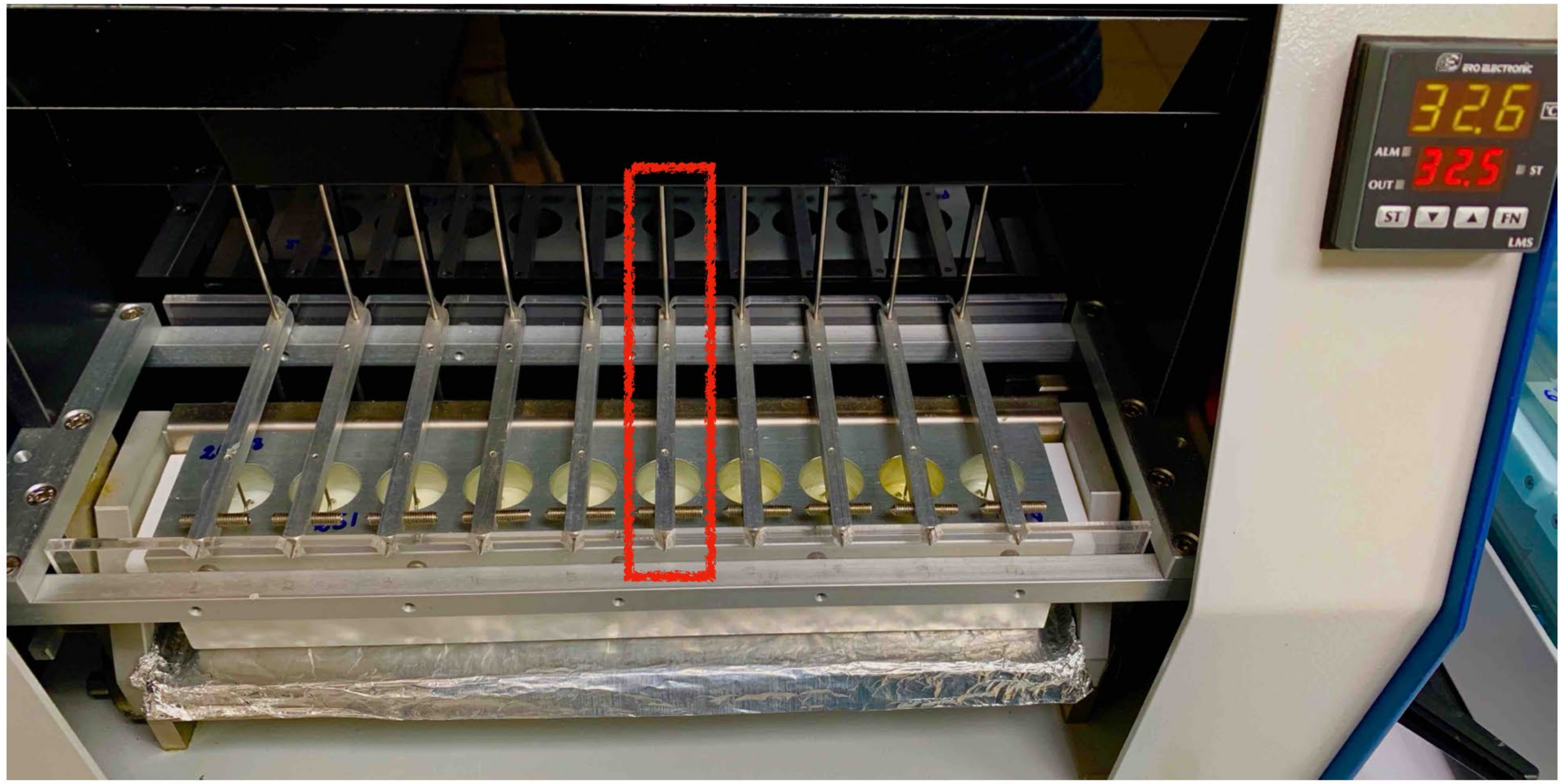
FOSSOMATICTM *MINOR CELL COUNTER*

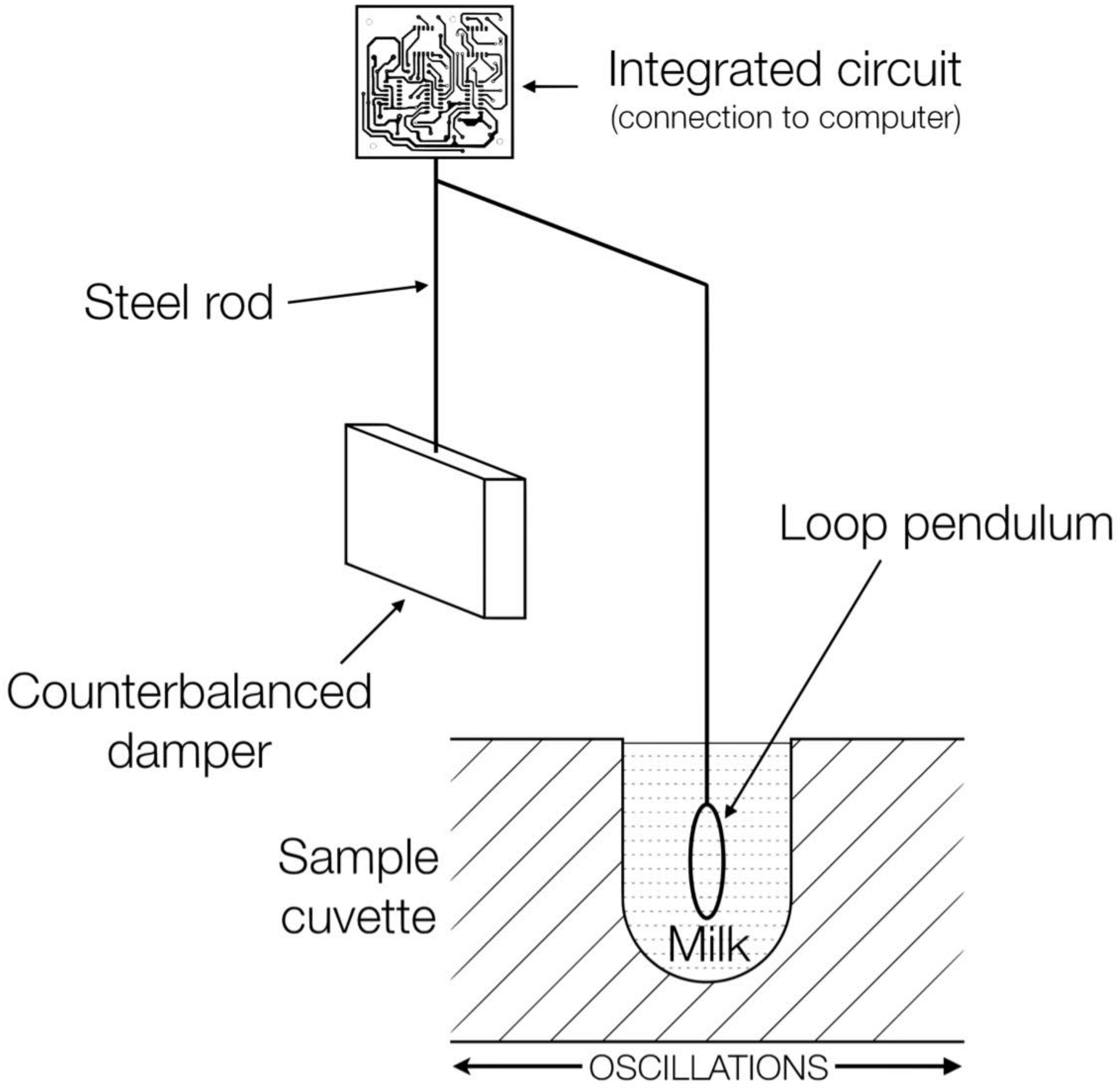


SCC normalized to SOMATIC CELL SCORE

Rennet coagulation

Renneting parameters were monitored using a Formagraph™ viscometer, based on the oscillatory motion of circular pendula immersed in milk during coagulation.

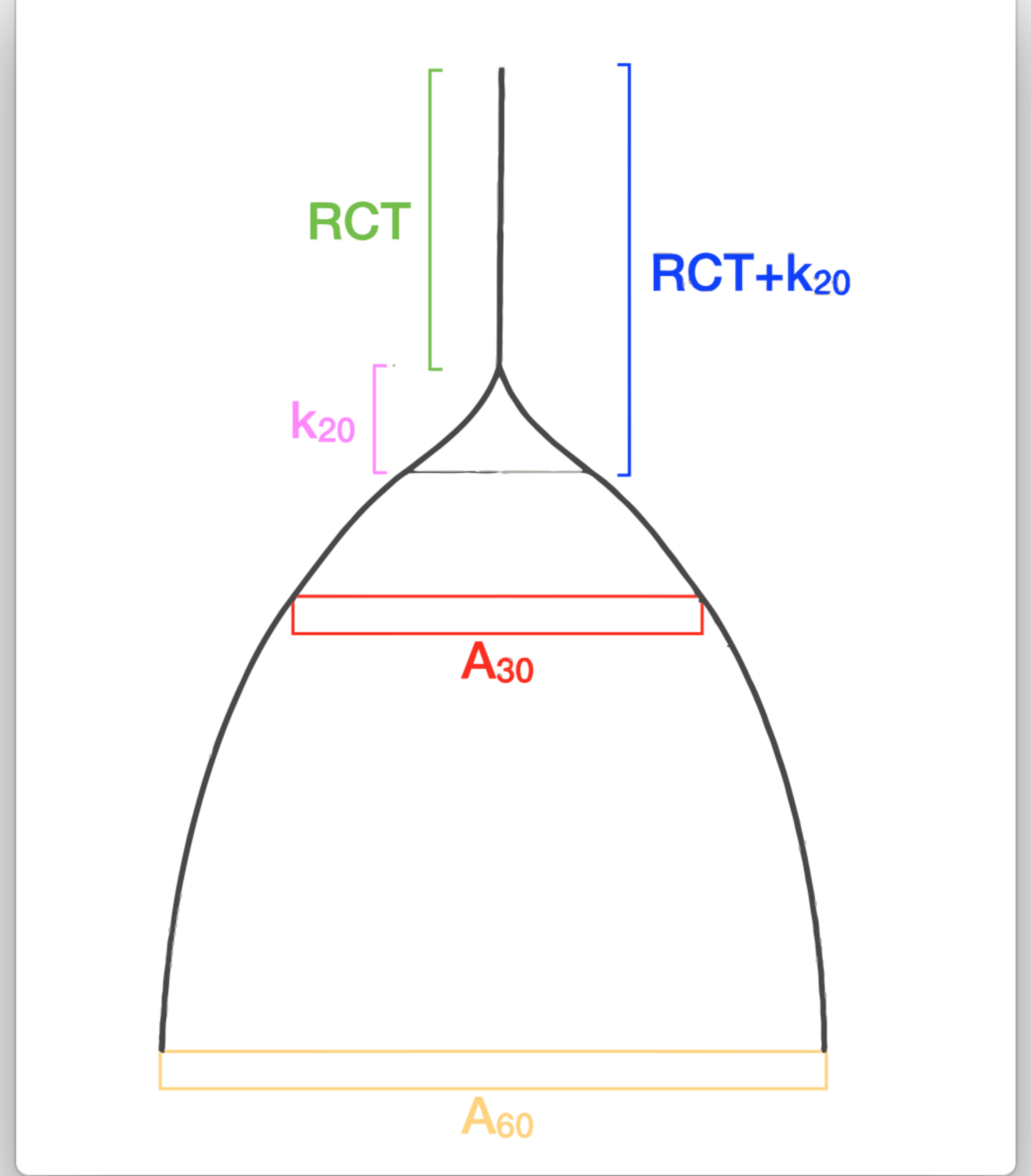




Rennet coagulation

Renneting parameters were monitored using a Formagraph™ viscometer, based on the oscillatory motion of circular pendula immersed in milk during coagulation.

DIAGRAM OF COAGULATION



- **RCT**: time elapsed (in minutes) until the formation of the curd.
- **k_{20}**: time (in minutes) from the start of gel development until a width of 20 mm is reached on the chart.
- **A_{30}**: width of the diagram (mm) at 30 minutes.
- **A_{60}**: width of the diagram (mm) at 60 minutes.

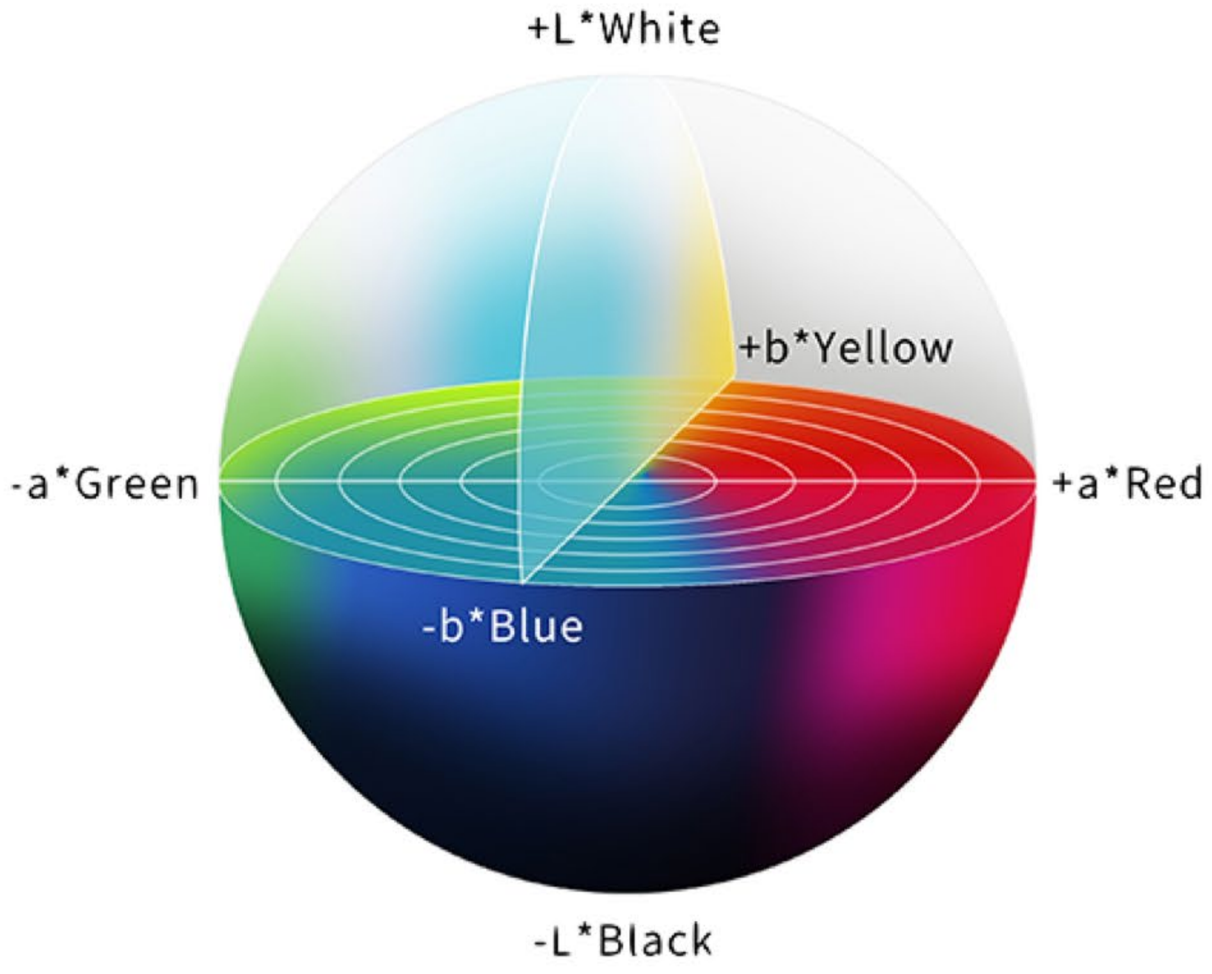
CURD YIELD
30 min 2800×*g*, 37 °C

DRY CURD YIELD
100 °C, 24 h

Colour in raw milk

For the measurement of colour values in milk we used a colour meter, which provided the values for brightness (L*) and chromaticity (a* and b*).

- **Brightness values (L*)** range from 0 (white) to 100 (black).
- **Cromaticity values** range from -60 to +60. Positive values for **a*** are associated to red and negative values to green. Positive values for **b*** are associated to yellow and negative values to blue. **C*** (chroma) and **h*** (hue) were then obtained using mathematical formulas (Daszkiewicz et al., 2012).



METHODOLOGY

Statistical analysis

Multivariate analysis techniques were used to analyze differences and similarities in colour, milk composition, and milk coagulation.

CANONICAL DISCRIMINANT ANALYSIS

THE MOST DISCRIMINANT VARIABLES OBTAINED WERE IDENTIFIED

STEPWISE DISCRIMINANT ANALYSIS

PERFORMED ON 4 SETS OF VARIABLES: COMPOSITION VARIABLES; COAGULATION VARIABLES; COLOR VARIABLES; AND THE WHOLE SET OF VARIABLES.

DISCRIMINANT ANALYSIS

THE PREDICTIVE ABILITY OF EACH MODEL IS TESTED USING THE ABSOLUTE ASSIGNMENT OF SAMPLES TO THE PREASSIGNED GROUP

RESULTS & DISCUSSION

Canonical discriminant analysis

The table emphasises the variables selected that showed higher discriminatory ability among species

Variable	Cow	Goat	Sheep	Wilks' λ	F-Value	p-Value	R^2	CAN1*	CAN2*
FAT	**2.44 ± 1.12 [c]**	**5.56 ± 1.23 [b]**	**6.54 ± 1.81 [a]**	**0.429**	**1518.51**	**<0.001**	**0.867**	**0.835**	**0.072**
CP	**4.18± 0.47 [b]**	**3.98 ± 0.54 [c]**	**5.59 ± 0.79 [a]**	**0.474**	**1264.47**	**<0.001**	**0.775**	**0.632**	**0.603**
LAC	4.62 ± 0.26 [c]	4.86 ± 0.45 [b]	4.95 ± 0.36 [a]	0.850	201.44	<0.001	0.283	0.427	0.052
pH	6.70 ± 0.08 [a]	6.66 ± 0.13 [b]	6.61 ± 0.14 [c]	0.898	130.12	<0.001	0.423	-0.343	-0.111
RCT	20.48 ± 6.00	20.07 ± 7.38	19.88 ± 10.03	0.999	1.07	0.343	0.473	-0.034	-0.005
k_{20}	9.39 ± 6.01 [a]	6.06 ± 3.95 [b]	3.53 ± 3.09 [c]	0.730	420.56	<0.001	0.518	-0.562	-0.145
A_{60}	30.94 ± 9.44	25.09 ± 9.65 [c]	38.69 ± 10.99 [a]	0.817	255.28	<0.001	0.384	0.280	0.464
CY	**16.64 ± 3.72 [c]**	**20.59 ± 4.78 [b]**	**26.76 ± 5.77 [a]**	**0.558**	**903.79**	**<0.001**	**0.879**	**0.695**	**0.295**
DCY	35.02 ± 4.09	42.17 ± 6.08 [a]	42.37 ± 5.43 [a]	0.694	502.89	<0.001	0.536	0.611	-0.059
L*	**78.27 ± 2.87 [c]**	**83.47 ± 1.28 [b]**	**83.61 ± 2.21 [a]**	**0.483**	**1221.35**	**<0.001**	**0.736**	**0.794**	**-0.077**
a*	**−4.13 ± 1.34**	**−1.12 ± 0.51 [a]**	**−2.46 ± 0.71 [b]**	**0.483**	**1217.35**	**<0.001**	**0.707**	**0.679**	**-0.505**
b*	2.52 ± 3.17 [c]	3.29 ± 1.22 [b]	4.49 ± 1.93 [a]	0.870	169.63	<0.001	0.572	0.377	0.159

* Correlation of each variable with the canonical function

Canonical discriminant analysis

The table emphasises the variables selected that showed higher discriminatory ability among species

Variable	Cow	Goat	Sheep	Wilks' λ	F-Value	p-Value	R^2	CAN1*	CAN2*
Composition									
FAT	**2.44 ± 1.12 ^{c}**	**5.56 ± 1.23 ^{b}**	**6.54 ± 1.81 ^{a}**	**0.429**	**1518.51**	**<0.001**	**0.491**	**0.855**	**-0.266**
CP	**4.18± 0.47 ^{b}**	**3.98 ± 0.54 ^{c}**	**5.59 ± 0.79 ^{a}**	**0.474**	**1264.47**	**<0.001**	**0.482**	**0.770**	**0.512**
LAC	4.62 ± 0.26 ^{c}	4.86 ± 0.45 ^{b}	4.95 ± 0.36 ^{a}	0.850	201.44	<0.001	0.021	0.441	-0.116
pH	6.70 ± 0.08 ^{a}	6.66 ± 0.13 ^{b}	6.61 ± 0.14 ^{c}	0.898	130.12	<0.001	0.077	-0.370	0.004
Coagulation									
RCT	20.48 ± 6.00	20.07 ± 7.38	19.88 ± 10.03	0.999	1.07	0.343	0.286	-0.038	0.004
k_{20}	9.39 ± 6.01 ^{a}	6.06 ± 3.95 ^{b}	3.53 ± 3.09 ^{c}	0.730	420.56	<0.001	0.467	-0.647	-0.048
A_{60}	30.94 ± 9.44	25.09 ± 9.65 ^{c}	38.69 ± 10.99 ^{a}	0.817	255.28	<0.001	0.223	0.385	0.797
CY	**16.64 ± 3.72 ^{c}**	**20.59 ± 4.78 ^{b}**	**26.76 ± 5.77 ^{a}**	**0.558**	**903.79**	**<0.001**	**0.307**	**0.819**	**0.289**
DCY	35.02 ± 4.09	42.17 ± 6.08 ^{a}	42.37 ± 5.43 ^{a}	0.694	502.89	<0.001	0.132	0.668	-0.374
Colour									
L*	**78.27 ± 2.87 ^{c}**	**83.47 ± 1.28 ^{b}**	**83.61 ± 2.21 ^{a}**	**0.483**	**1221.35**	**<0.001**	**0.605**	**0.821**	**0.564**
a*	**−4.13 ± 1.34**	**−1.12 ± 0.51 ^{a}**	**−2.46 ± 0.71 ^{b}**	**0.483**	**1217.35**	**<0.001**	**0.597**	**0.903**	**-0.047**
b*	2.52 ± 3.17 ^{c}	3.29 ± 1.22 ^{b}	4.49 ± 1.93 ^{a}	0.870	169.63	<0.001	0.409	0.300	0.504

* Correlation of each variable with the canonical function

Stepwise discriminant analysis

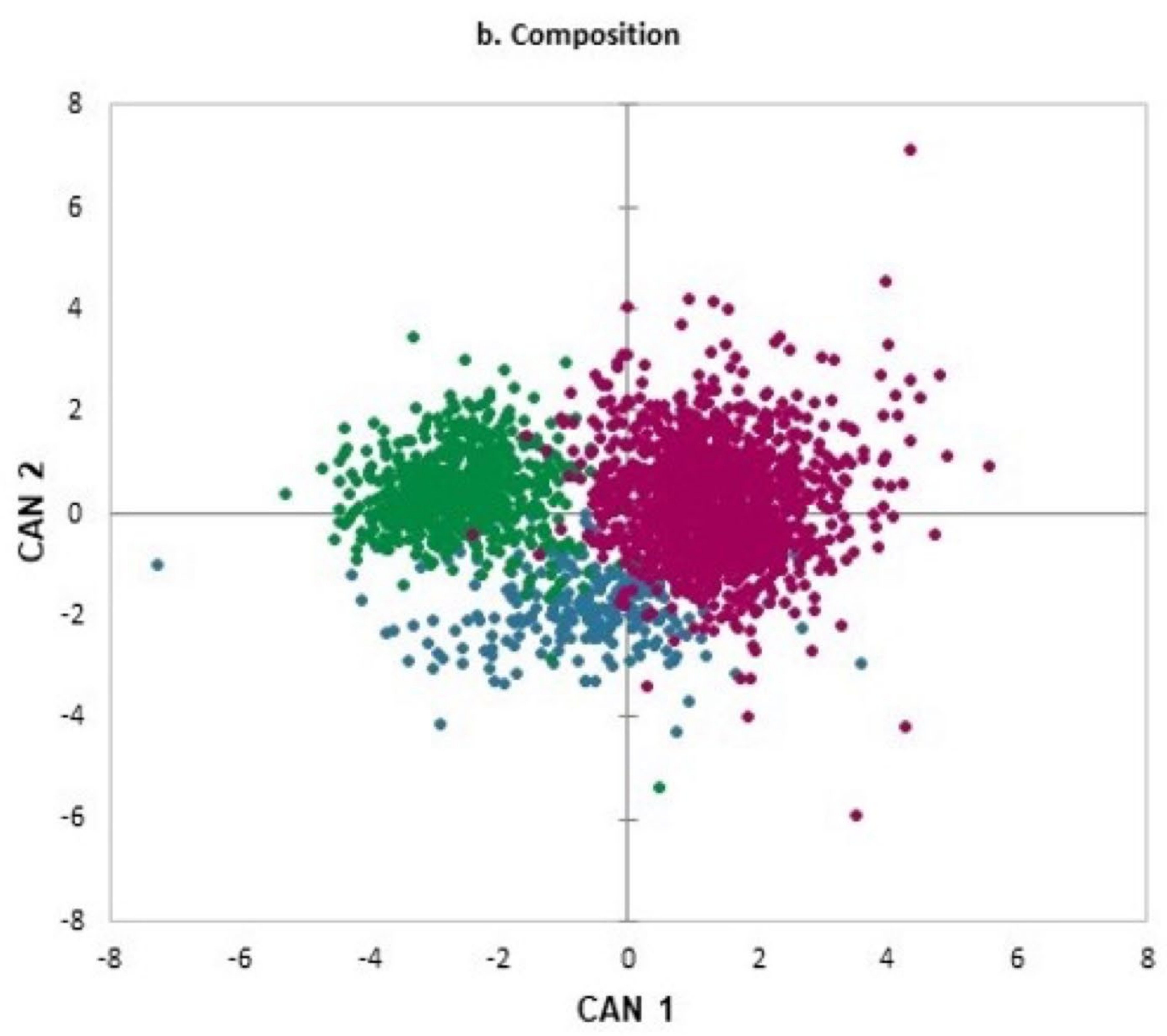
Discriminant canonical models for composition, coagulation, colour, and the whole set of variables.

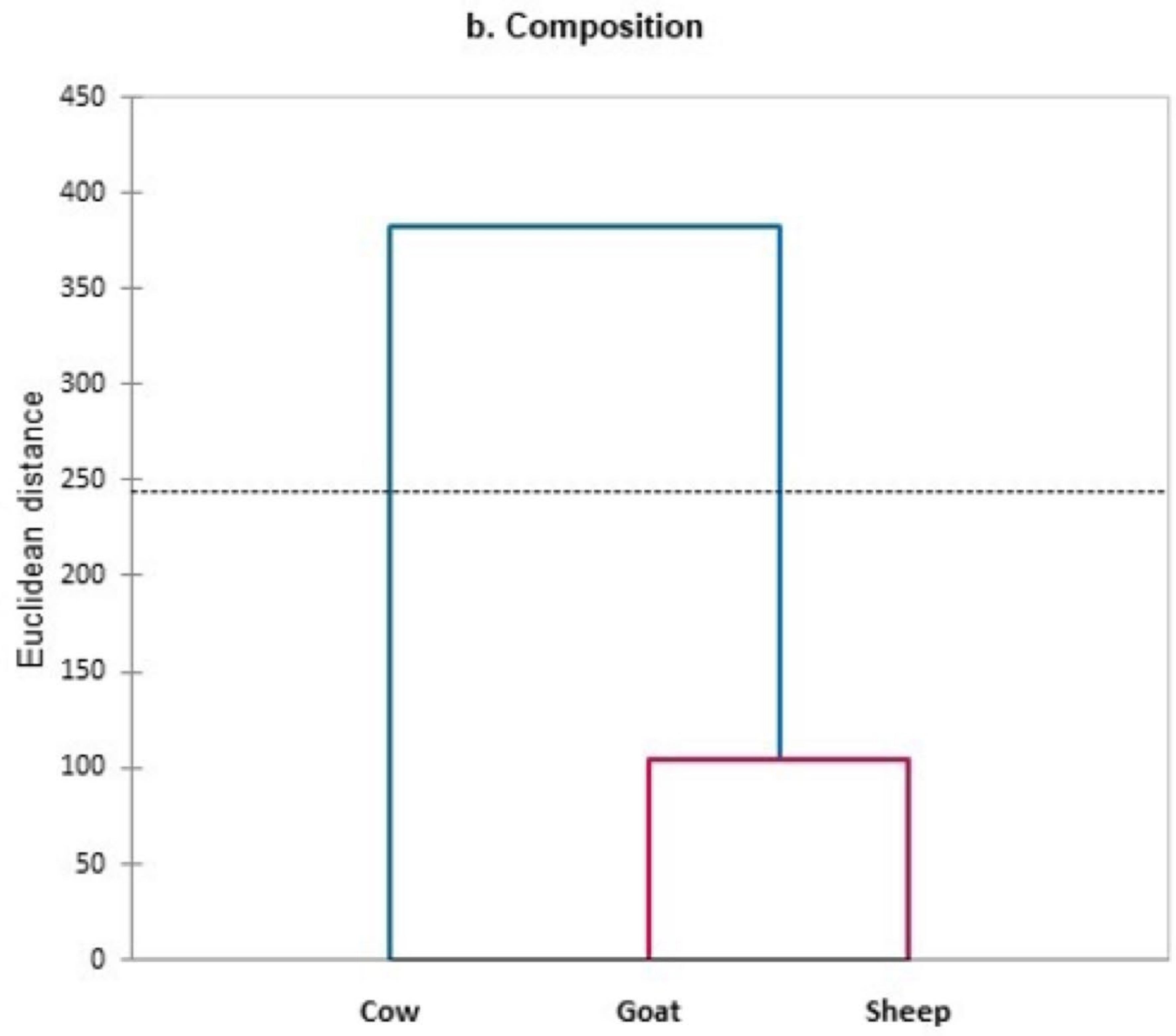
Model	No. Variables in model	Wilks' λ	F-Value	p-Value
Whole set	12	0.083	468.30	<0.001
Composition	**4**	**0.172**	**802.49**	**<0.001**
Coagulation	5	0.308	364.78	<0.001
Colour	**3**	**0.261**	**725.89**	**<0.001**

In all cases, the extracted canonical functions significantly discriminated among the three species. The F-statistics revealed a higher discriminating ability for the variables related to milk composition and colour.

Canonical discriminant analysis (composition)

Graphical representation of the results obtained by canonical discriminant analysis for milk composition variables, defined by the axes of the first 2 canonical variables.

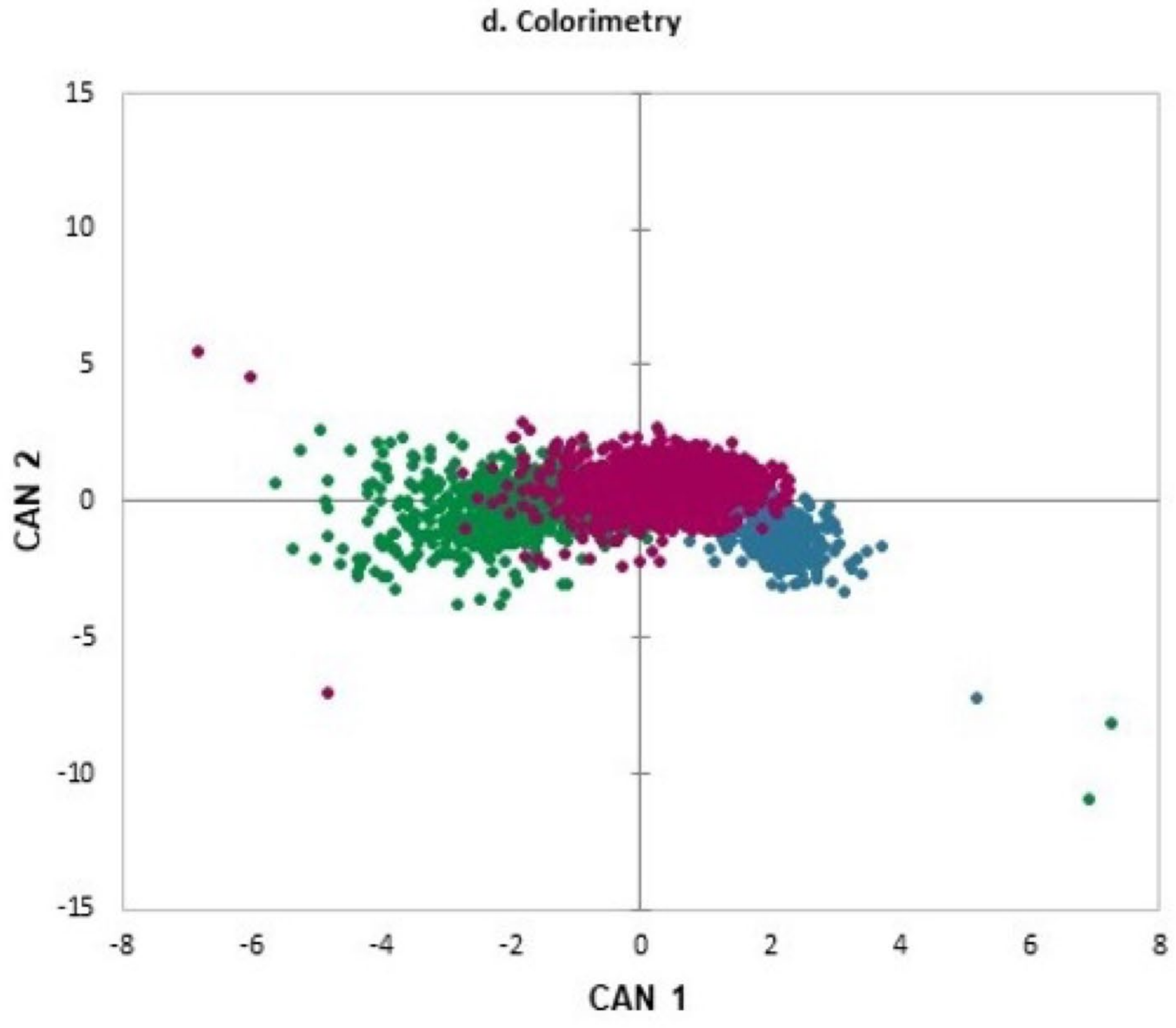


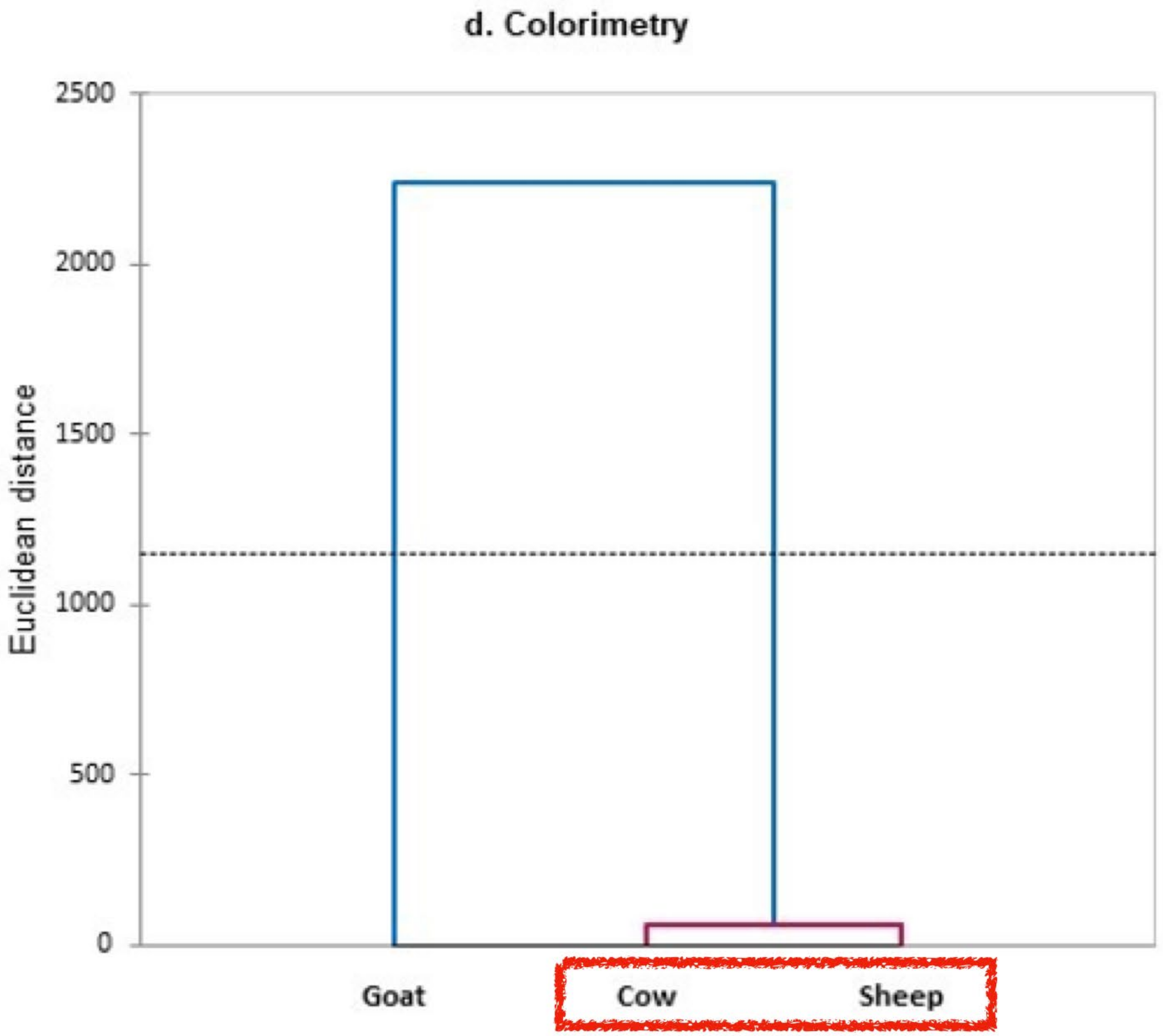


● COW ● GOAT ● SHEEP

Canonical discriminant analysis (colour)

Graphical representation of the results obtained by canonical discriminant analysis for the colour variables, defined by the axes of the first 2 canonical variables.





COW GOAT SHEEP

Discriminant analysis

Assignation percentages in the predefined groups and classification errors.

Model	Goat	Cow	Sheep
All variables			
Goat	94.72	1.51	3.77
Cow	0.15	98.66	1.19
Sheep	1.49	0.59	97.92
Error level	0.08	0.02	0.01
Composition			
Goat	87.92	3.02	9.06
Cow	3.86	94.95	1.19
Sheep	8.25	0.59	91.16
Error level	0.37	0.02	0.01
Coagulation			
Goat	76.98	6.04	16.98
Cow	10.57	86.90	2.53
Sheep	17.25	1.78	80.97
Error level	0.60	0.06	0.05
Colour			
Goat	96.23	0.38	3.40
Cow	0.00	85.88	14.12
Sheep	3.64	7.50	88.86
Error level	0.16	0.15	0.08

97.8%

91.9%

82.2%

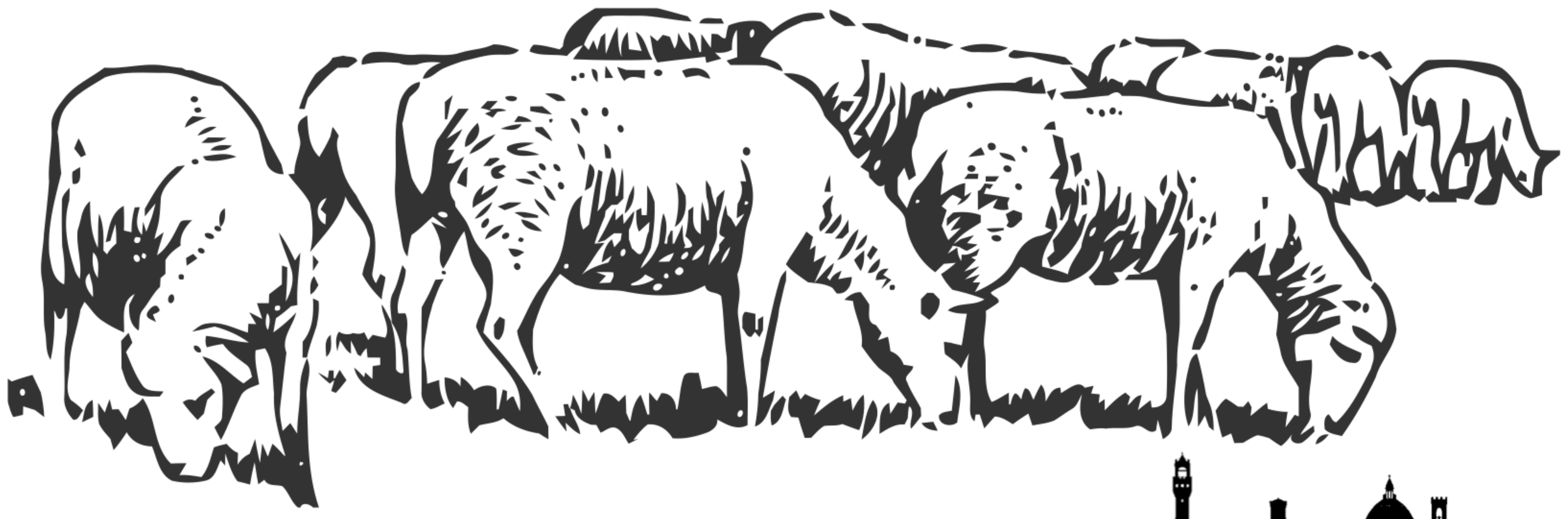
88.8%

Canonical correlation analysis

Correlation coefficients between variables and canonical variables included in the canonical correlation analysis.

Variable	CANONICAL COMPONENT					
	COW		GOAT		SHEEP	
	F_1	F_2	F_1	F_2	F_1	F_2
Composition—coagulation models						
pH	-0.324	**0.823**	-0.150	-0.104	0.217	**0.890**
FAT	**-0.829**	-0.359	**0.809**	**0.569**	**-0.954**	-0.127
CP	**-0.800**	-0.112	**0.825**	**-0.519**	**-0.864**	0.184
LAC	-0.119	-0.455	-0.076	-0.126	-0.087	-0.301
RCT	-0.449	**0.661**	-0.078	-0.322	-0.117	**0.898**
k_{20}	0.151	**0.702**	-0.397	0.409	0.499	0.478
A_{60}	**-0.633**	0.251	0.234	**-0.563**	**-0.627**	0.161
CY	**-0.952**	-0.157	**0.968**	0.010	**-0.948**	0.103
DCY	**-0.561**	-0.231	0.130	-0.346	**-0.555**	-0.446
Composition—colorimetric models						
pH	-0.091	**0.677**	-0.199	0.272	-0.099	**-0.774**
FAT	**-0.865**	0.260	**0.943**	0.257	**0.899**	0.165
CP	**-0.796**	-0.154	**0.618**	**-0.755**	**0.823**	-0.228
LAC	-0.337	**-0.671**	-0.360	-0.239	**-0.793**	0.350
L*	**-0.920**	-0.166	**0.653**	-0.136	0.472	**0.840**
a*	-0.055	**0.869**	**0.746**	**0.516**	**0.748**	0.371
b*	**-0.791**	0.490	**0.985**	-0.040	**0.951**	-0.186

Variable	CANONICAL COMPONENT					
	COW		GOAT		SHEEP	
	F_1	F_2	F_1	F_2	F_1	F_2
Coagulation—colorimetric models						
RCT	-0.255	**0.630**	0.028	**-0.820**	0.191	**-0.630**
k_{20}	0.227	**0.735**	0.041	**-0.693**	-0.119	**-0.712**
A_{60}	-0.493	-0.426	0.138	**0.793**	0.324	-0.401
CY	**-0.966**	0.096	**-0.852**	0.153	**0.840**	-0.080
DCY	0.314	**-0.501**	-0.361	0.026	0.265	0.271
L*	**-0.889**	-0.104	**-0.673**	**0.590**	**0.526**	**0.836**
a*	-0.187	**0.982**	**-0.821**	-0.120	**0.735**	0.272
b*	**-0.851**	0.150	**-0.983**	0.185	**0.953**	-0.212



Improvements & **further actions**

This field of research should be continued considering several aspects.

LIMITATIONS OF THE STUDY

- SCC
- SIMPLE MODELS
- OTHER MILK COMPOUNDS

foods MDPI

Article

Exploring Interrelationships between Colour, Composition, and Coagulation Traits of Milk from Cows, Goats, and Sheep

Ana Garzón [1], José M. Perea [1], Elena Angón [1], Eoin G. Ryan [2], Orla M. Keane [3] and Javier Caballero-Villalobos [1,*]

FURTHER ACTIONS

1. Application of the developed methodology on milk from individual animals from different breeds.
2. Development and assessment of more complex models that include other variables in order to fine-tune the predictive ability of colour values in milk processing into cheese.
3. Exploration of colour measurements as a potential tool to assess the presence of bacteria in milk.

CONCLUSIONS

Conclusions and proposed actions

1. Colour can be used to effectively discriminate milk at a species level. It can also help predict if milk will coagulate under laboratory conditions.

2. While milk quality traits show some common patterns of variations, strong species-specific relationships emerge, highlighting the connection between milk colour and curd yield.

3. These findings may allow to model these relationships to estimate milk technological performance, potentially leading to an optimization of the coagulation process beneficial for the cheesemaking industry.

EAAP · EUROPA · FEZ · EVT · EAK

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THANK YOU

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