EAAP
European Federation of Animal Science

Uncovering environmental effects and genetic parameters on the mineral composition of sheep milk

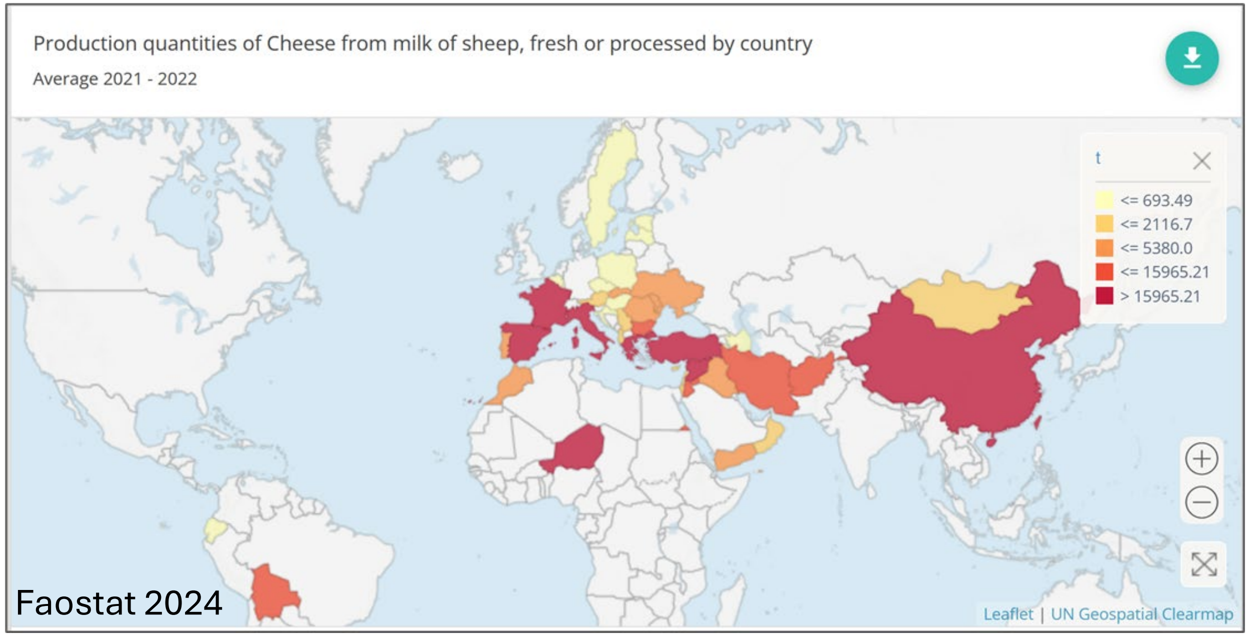
Johanna Ramírez-Díaz[1], Giorgia Stocco[2], Claudio Cipolat-Gotet[2], M. Ablondi[2], A. Summer[2], Alessio Negro[3], Alessandro Lotto[4], Simone Blotta[4], Francesco Tiezzi[5], Stefano Biffani[1]

[1]National Research Council, Institute of Agricultural Biology and Biotechnology, Milano, Italy, [2]University of Parma, Dep. of Veterinary Science, Parma, Italy, [3]Associazione Nazionale della Pastorizia (Asso.Na.Pa.), Ufficio Studi, Roma, Italy, [4]Nutristar spa, Reggio Emilia, Italy,[5] Department of Agriculture, Food, Environment and Forestry, Università degli Studi di Firenze, Firenze, Italy

INTRODUCTION

Cheese Industry

- The global dairy sheep cheese production reached 1.5 million metric tons in 2021-2022



- The sheep cheeses production in Italy in 2022 was approximately 37 tonnes

Rural context and development

The sheep production systems:

- Importance in the rural context: Challenges to produce other species
- Nutritional composition and taste of dairy products
- Higher quality composition

INTRODUCTION

Average values of sheep milk composition:

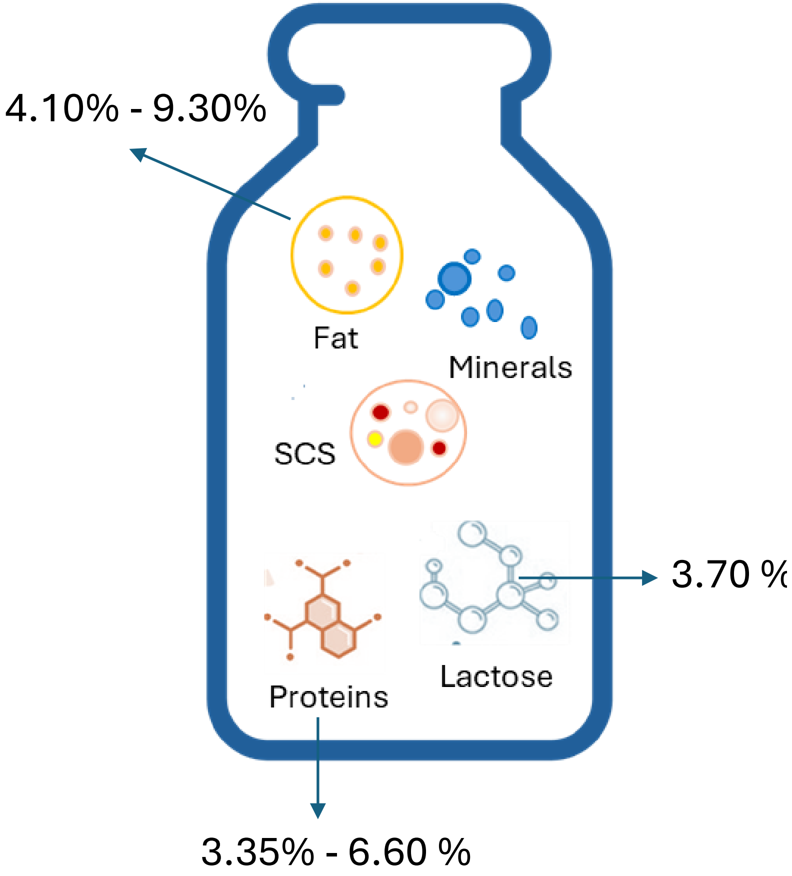
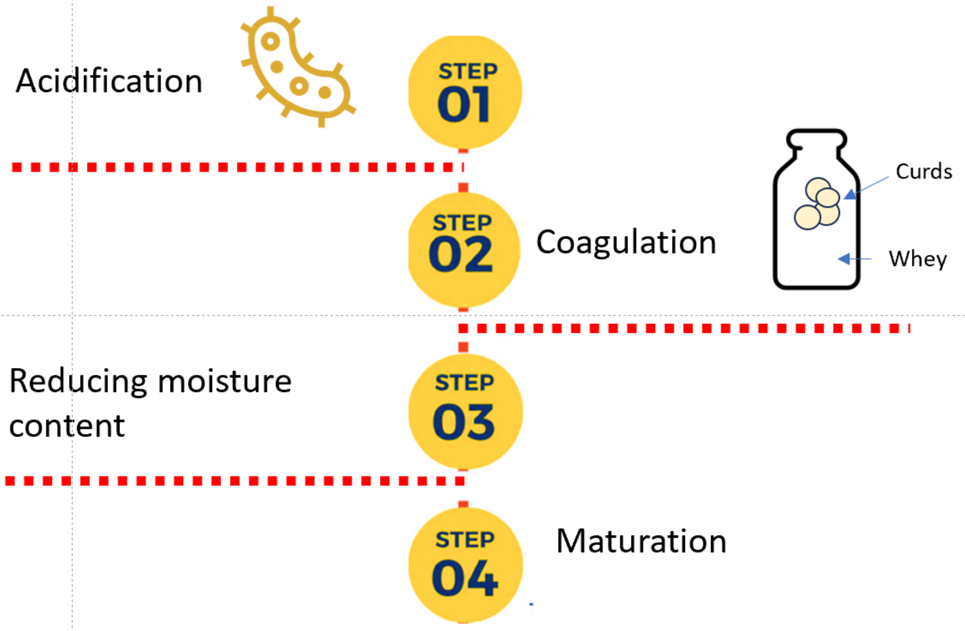


Table 5–Concentration of minerals in milk from vario

	Cattle[e]	Sheep[g]
(mg/100 g)		
Calcium	122	195 to 200
Phosphorus	119	124 to 158
Potassium	152	136 to 140
Magnesium	12	18 to 21
Sodium	58	44 to 58
(μg/100 g)		
Zinc	530	520 to 747
Iron	80	72 to 122
Copper	60	40 to 68
Manganese	20	5.3 to 9
Iodine	2.1	10.4
Selenium	0.96	3.1

[a]Schryver and others (1986); [b]Mehaia and others (1995); [c]Salimei and ot
Haj and Al Kanhal (2010).

Barłowska et al., 2011



Ca, Na, K and S -> Dairy Cattle

INTRODUCTION

Limited and almost non-existent in local breeds -> Cheese production -> environmental adaptation, traditions and cultural heritage

NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH
https://doi.org/10.1080/00288233.2024.2368505

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Estimation of genetic parameters for production, composition and processability of milk from dairy sheep in a New Zealand flock

Ana Carolina Marshall[a,b], Nicolas Lop
Mike Weeks[d] and Warren McNabb[b]

[a]Department of Animal Science, School of Agricultu
New Zealand; [b]The Riddet Institute, Massey Unive
Scientific and Industrial Research Organisation (C
Foods & Bioproducts Group, AgResearch Ltd, Mas

ELSEVIER

Journal of Da
Available onlin
In Press, Journal Pre-pro

Detailed mineral profile
cheese from cows, buff
and dromedary camels, and efficiency of recovery of minerals in their cheese

Nicolò Amalfitano[1], Nageshvar Patel[1], Mohamed-Laid Haddi[2], Hamida Benabid[3], Michele Pazzola[4], Giuseppe Massimo Vacca[4], Franco Tagliapietra[1], Stefano Schiavon[1], Giovanni Bittante[1]

Research

Estimation of genetic parameters for cheese-making traits in Spanish Churra sheep

R. Pelayo[1], B. Gutiérrez-Gil[1], A. Garzón[2], C. Esteban-Blanco[1], H. Marina[1], J.J. Arranz[1]

Show more

Cite

Get rights and content

open archive

710. Heritability and genomic analysis of coagulation event in sheep milk

G. Gaspa, A. Cesarani, F. Correddu, M. Congiu, C. Dimauro, A. Pauciullo, N.P.P. Macciotta

Pages: 2928 - 2931

OPEN ACCESS

https://doi.org/10.3920/978-90-8686-940-4_710

Published Online: February 09, 2023

Abstract | References | Full-text

61.
.12552

PMCID: PMC8453569
PMID: 34014003

lerlying milk production traits in Valle del Belice
bility mapping

Anna Maria Sutera,[1] Marco Tolone,[2] Salvatore Mastrangelo,[2] Rosalia Di Gerlando,[2] Maria Teresa Sardina,[2] Baldassare Portolano,[2] Ricardo Pong-Wong,[3] and Valentina Riggio[3,4]

Author information · Article notes · Copyright and License information · PMC Disclaimer

INTRODUCTION

- In general, sheep breeding programs are related to Milk yield, Meat and growth traits and disease resistance → Programs to improve the cheese making process don’t exist → mineral composition

- The role of minerals in improving milk composition and quality → for cheese production

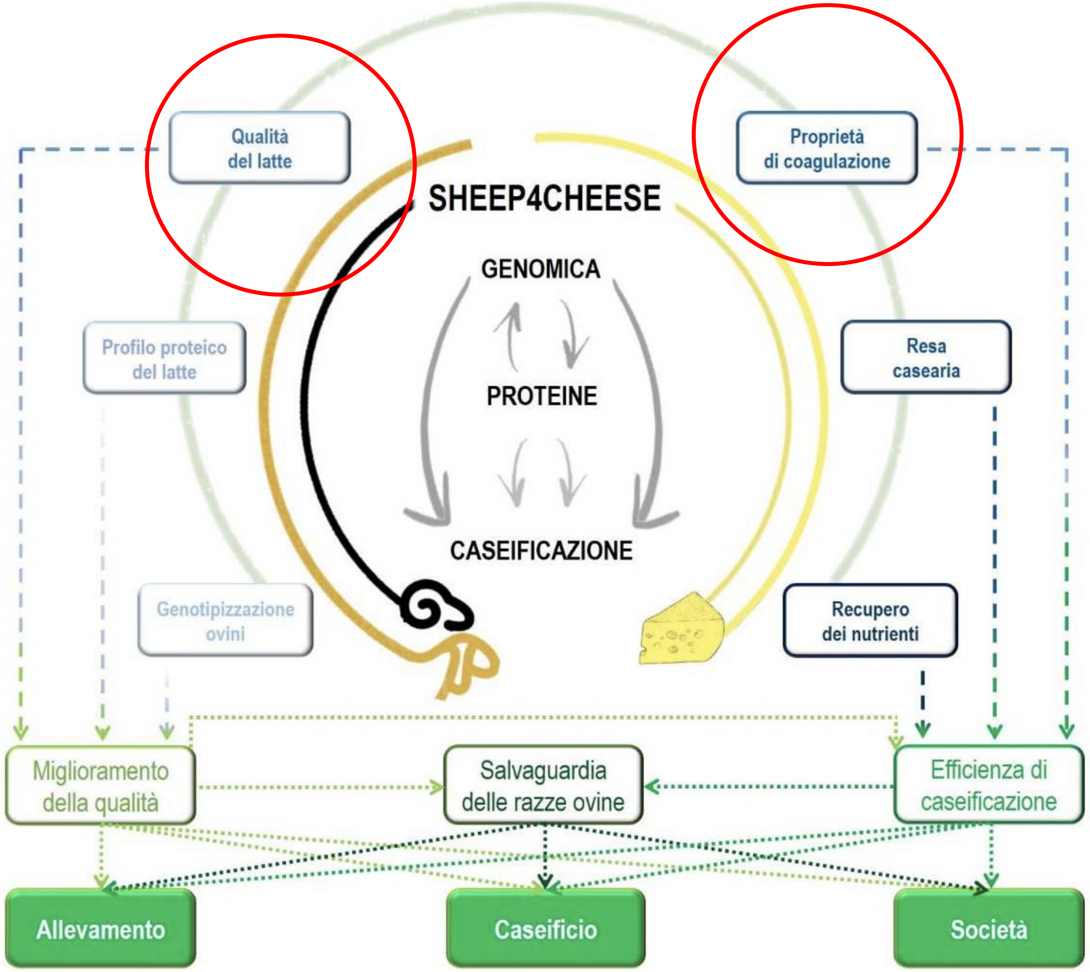
- Genetic programs → Have permanent and cumulative changes in economic important traits:
  - Step 1: To guide effective breeding strategies is necessary to estimate variance components and genetic parameters

SHEEP4CHEESE

Aim:

Improving the milk quality and efficiency of cheese-making process

To improve the quality of the sheep milk through genetic selection of the animals



Objectives

General plan of activities to assess the composition and mineral content:

Genotyping

Parental information from Massese and Comisana Sheep

Phenotyping

Evaluations of Mineral contents and milk composition

Evaluation of coagulation and cheese making process

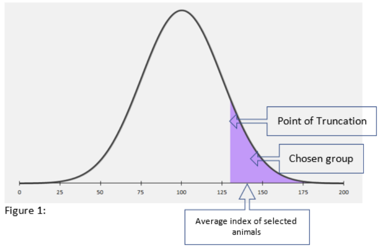
1. Data analysis

2. Statistical modelling

3. Genetic parameters
Single and multitrait models

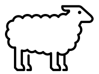
4. Genome wide association analyses
Single, multitrait models and pleiotropic effects

5. GEBVs and EBVs estimation
Selection to economical important traits and genetic gain prediction

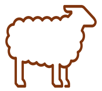


MATERIAL

Italian Apenines



Massese sheep
n = 311



Comisana sheep
n = 429

Central and Southern Italy

Milk samples
Morning milking
11 sampling season

Laboratory analysis

%Fat, %Protein, %Caseina, %Lactose
MilkoScan FT3 infrared analyser

+

Somatic Cell Score
Fossomatic DC7 somatic cell counter

+

pH
Crison Basic 25 portable pH meter

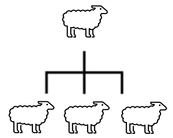
+

Ca, P, Na, K, Mg, S, Cl
Wavelength Dispersive X-ray fluorescence

To explain this:

Inclusion of environmental factors: animal status, sampling and other traits

Inclusion of genetic information



Pedigree:
Comisana: 742,851 animals
(sires: 15033 and 172,481 dams)
Massese: 132,685
(sires: 3014 and 45626 dams).

METHODS

Sampling

Additive genetic Effects

$$y_t = X\beta + Wc + Zu + e$$

Quality Control

Missing information
Biological Thresholds
....
Distribution on PO
Distribution on DIM

DIM:
Class 1: 8 -30d ,
Class 2: 31 -50d ;
Class 3: 51-70d ;
Class 4: 71-90d ;
Class 5: 91-110d;
Class 6: 111 -130d ;
Class 7: 131-148d

Milk Yield
class 1: 0.3 – 0.55 kg;
class 2: 0.6 – 0.79 kg;
class 3: 0.8 – 0.97 kg;
class 4: 1 – 2.33 kg

Parity Order:
1;2;3;4; > 5

Fat %

Casein %

Lactose %

pH

SCS

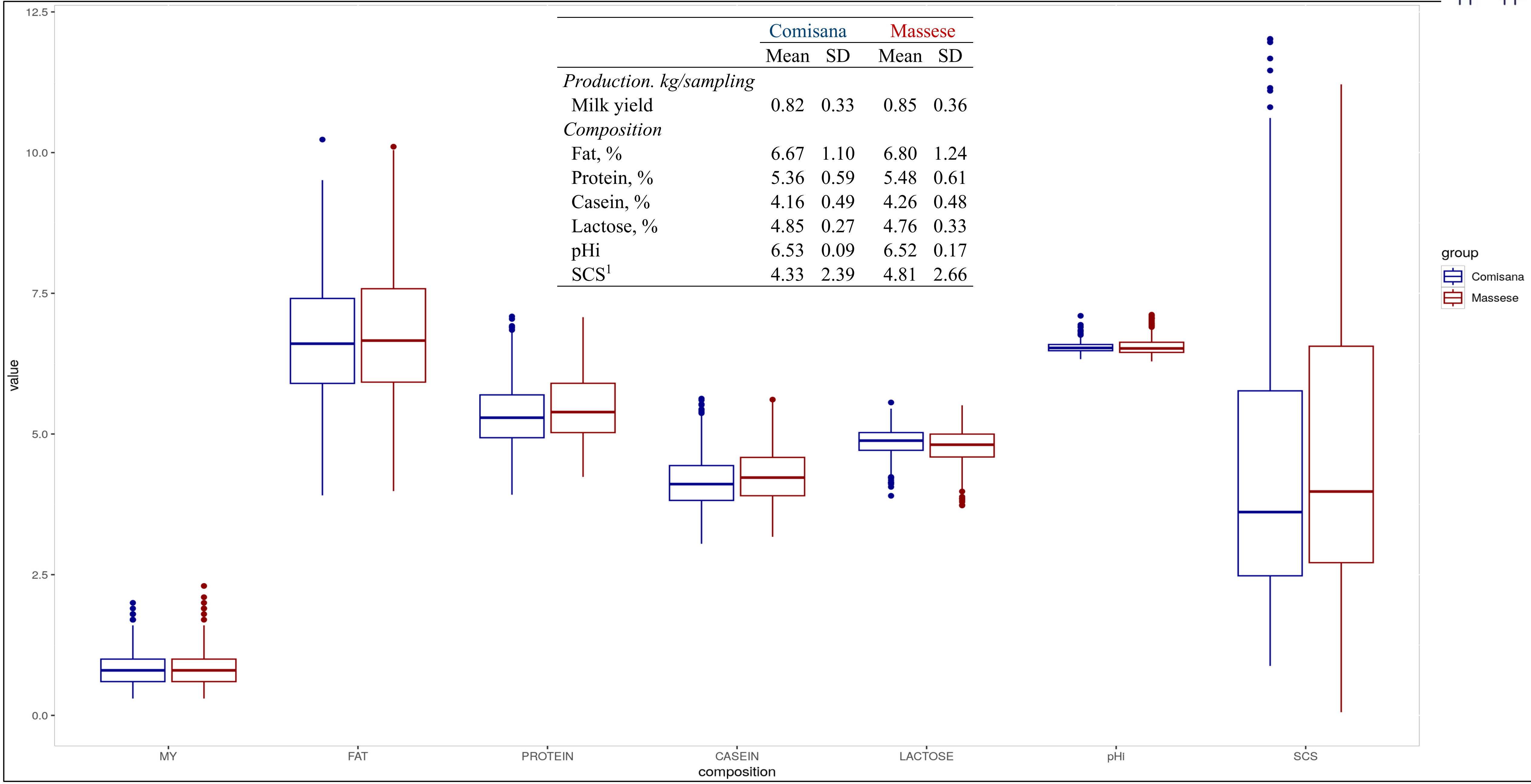
RESULTS

	Co	Ma	Co	Ma	Co	Ma	Co	Ma	Co	Ma	Co	Ma	Co	Ma
	Ca		**P**		**Mg**		**S**		**Na**		**K**		**Cl**	
Systematic effects														
Parity Order		*		*	*	*		*	*		*	*	*	*
DIM	*		*		*		*		*			*	*	
MY		*	*	*		*		*	*	*	*	*		*
Fat	*	*			*	*	*		*	*				*
Casein	*		*	*		*	*	*	*	*				
Lactose		*			*		*	*	*		*	*	*	*
pH		*		*		*	*	*		*		*		*
SCS[1]			*	*	*				*	*		*	*	*
Random Effects														
Direct additive genetic effects	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sampling	*	*	*	*	*	*		*	*	*		*	*	*
Residual	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Co: Comisana
Ma: Massese
*p > 0.05

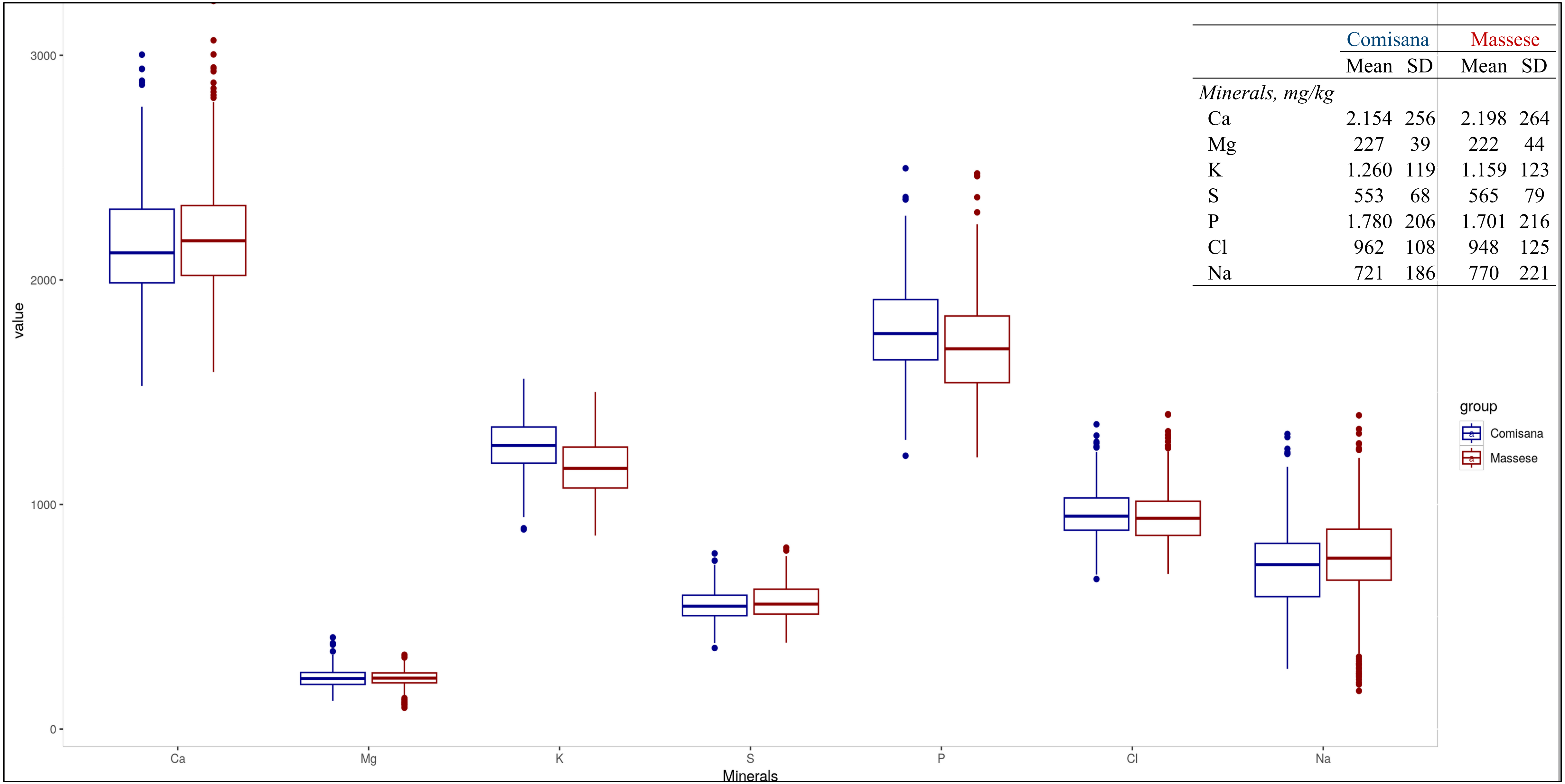
The specific significant effects on individual minerals were not exactly the same!!!

RESULTS



	Comisana		Massese	
	Mean	SD	Mean	SD
Production. kg/sampling				
Milk yield	0.82	0.33	0.85	0.36
Composition				
Fat, %	6.67	1.10	6.80	1.24
Protein, %	5.36	0.59	5.48	0.61
Casein, %	4.16	0.49	4.26	0.48
Lactose, %	4.85	0.27	4.76	0.33
pHi	6.53	0.09	6.52	0.17
SCS[1]	4.33	2.39	4.81	2.66

RESULTS



	Comisana		Massese	
	Mean	SD	Mean	SD
Minerals, mg/kg				
Ca	2.154	256	2.198	264
Mg	227	39	222	44
K	1.260	119	1.159	123
S	553	68	565	79
P	1.780	206	1.701	216
Cl	962	108	948	125
Na	721	186	770	221

RESULTS

	Comisana	Massese
	h^2 + SE	$h^2 + SE$
Production, kg/sampling		
Milk yield	0.14 ± 0.10	0.29 ± 0.14
Composition		
Fat, %	0.22 ± 0.11	0.15 ± 0.10
Protein, %	0.10 ±0.06	0.34 ± 0.14
Casein, %	0.30 ± 0.11	0.28 ± 0.14
Lactose, %	0.31 ± 0.10	0.29 ± 0.13
SCS[1]	0.081 ± 0.06	0.28 ± 0.12

	Comisana	Massese
	h^2 + SE	h^2 + SE
Minerals, mg/kg		
Ca	0.45 ± 0.11	0.41 ± 0.17
P	0.49 ± 0.12	0.17 ± 0.11
Mg	0.25 ± 0.12	0.16 ± 0.11
S	0.34 ± 0.10	0.14 ± 0.11
K	0.40 ± 0.11	0.28 ± 0.12
Na	0.29 ± 0.12	0.14 ± 0.14
Cl	0.42 ± 0.10	0.17 ± 0.12

- ✓ Differences highlight the need for breed-specific investigations to characterize the complex relationships between milk composition and mineral content
- ✓ The synthesis of the minerals in milk depend several factors that include the diet and nutrition, stress and illness, hormonal levels, but also genetic factors that can be determinate the absorption, transport and metabolism

Heritability reported for composition milk sheep

Higher variability of heritability estimates in Sheep Breeds !!!

Table 2
Pooled estimates of heritability from meta-analysis in dairy sheep.

Trait[1]	Pooled h^2 (±SE)	Min[2] h^2	Max[3] h^2	N obs[4]	N studies	I^2 between[5]	I^2 within[6]
MY	0.24 ± 0.02	0.06	0.46	29	19	83.98	15.03
FY	0.21 ± 0.06	0.14	0.28	7	5	0.26	96.7
PY	0.22 ± 0.04	0.12	0.30	7	5	0.64	95.77
FC	0.28 ± 0.11	0.04	0.68	16	12	54.79	45.13
PC	0.33 ± 0.07	0.10	0.77	25	17	62.58	37.2
SCS	0.13 ± 0.02	0.03	0.27	29	22	52.64	44.26
FEC	0.14 ± 0.04	0.09	0.35	6	3	0	57.97

SCS – somatic cell score, FEC – faecal egg count.
[1] Trait: MY – milk yield, FY – fat yield, PY – protein yield, FC – fat content, PC – protein content.
[2] Minimum h^2 from individual studies included in meta-analysis.
[3] Maximum h^2 from individual studies included in meta-analysis.
[4] Number of observations used in meta-analysis.
[5] Heterogeneity between clusters.
[6] Heterogeneity within clusters.

Mucha et al., 2022

Heritability reported for composition milk sheep

Genetic (co)variances between milk mineral concentration and chemical composition in lactating Holstein-Friesian dairy cows

G. Visentin[1], G. Niero[1] ✉, D.P. Berry[2], A. Costa[1], M. Cassandro[1], M. De Marchi[1], M. Penasa[1]

Table 1. Mean, genetic standard deviation (s_g), heritability (h^2; standard error in parentheses), repeatability (t; standard error in parentheses) and coefficient of genetic variation (CV_g) estimated using the repeatability animal model for calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and phosphorus (P) concentration, chemical composition, pH and somatic cell score (SCS) of cow milk

Traits	*n*	Mean	σ_g	h^2	*t*	CV_g (%)
Ca (mg/kg)	12 208	1295.29	85.58	0.54 (0.04)	0.66 (0.01)	6.61
K (mg/kg)	12 165	1684.48	56.09	0.19 (0.03)	0.25 (0.01)	3.33
Mg (mg/kg)	12 198	136.89	7.88	0.21 (0.03)	0.27 (0.01)	5.76
Na (mg/kg)	12 223	439.06	21.56	0.24 (0.04)	0.39 (0.02)	4.91
P (mg/kg)	12 220	995.04	62.25	0.42 (0.04)	0.53 (0.01)	6.23

RESULTS

Genetic correlation matrix among milk yield (MY), composition and minerals in Comisana (above the diagonal) and Massese (below the diagonal) breeds.

			Comissana												
			Composition %						*Minerals, mg/kg*						
			MY	Fat	Protein	Casein	Lactose	SCS[1]	Ca	P	Mg	S	K	Na	Cl
Massese		MY	*	0.55	0.35	0.10	-0.07	0.51	-0.61	-0.19	-0.36	0.30	-0.09	0.04	-0.65
	Composition	Fat, %	0.38	*	0.51	NC	-0.89	NC	0.08	0.16	0.07	-0.10	-0.68	NC	0.13
		Protein, %	NC	0.21	*	NC	0.32	-0.66	0.33	0.33	0.33	NC	-0.51	0.22	-0.44
		Casein, %	NC	NC	NC	*	-0.13	-0.47	0.20	0.26	0.25	NC	-0.20	0.21	-0.41
		Lactose, %	NC	NC	NC	0.28	*	NC	0.08	-0.22	-0.40	-0.10	-0.89	NC	0.64
		pH													
		SCS[1]	NC	NC	- NC	0.19	NC	*	-0.22	-0.50	NC	-0.19	NC	NC	NC
	Minerals, mg/kg	Ca	-0.35	-0.51	0.071	0.33	0.49	-0.08	*	0.66	0.67	0.30	-0.30	0.62	0.27
		P	-0.40	-0.48	-0.038	0.016	-0.045	-0.32	0.25	*	NC	0.35	0.05	0.51	0.04
		Mg	-0.22	-0.73	-0.37	0.013	-0.26	0.23	-0.39	0.24	*	0.47	-0.023	0.74	0.10
		S	-0.34	-0.54	0.046	0.17	-0.006	-0.13	-0.33	0.66	0.57	*	-0.37	0.43	-0.24
		K	-0.11	-0.59	-0.42	-0.01	-0.78	NC	-0.10	0.010	0.34	-0.037	*	-0.31	0.52
		Na	-0.80	-0.53	-0.36	-0.38	-0.79	NC	-0.53	0.61	0.79	NC	0.35	*	0.11
		Cl	-0.30	0.03	-0.60	-0.60	-0.70	0.88	-0.74	-0.74	0.039	-0.18	0.01	0.26	*

[1]SCS = $\log_2$(somatic cell count × 10^{-5}) + 3

Genetic correlation reported for SCS and Milk yield

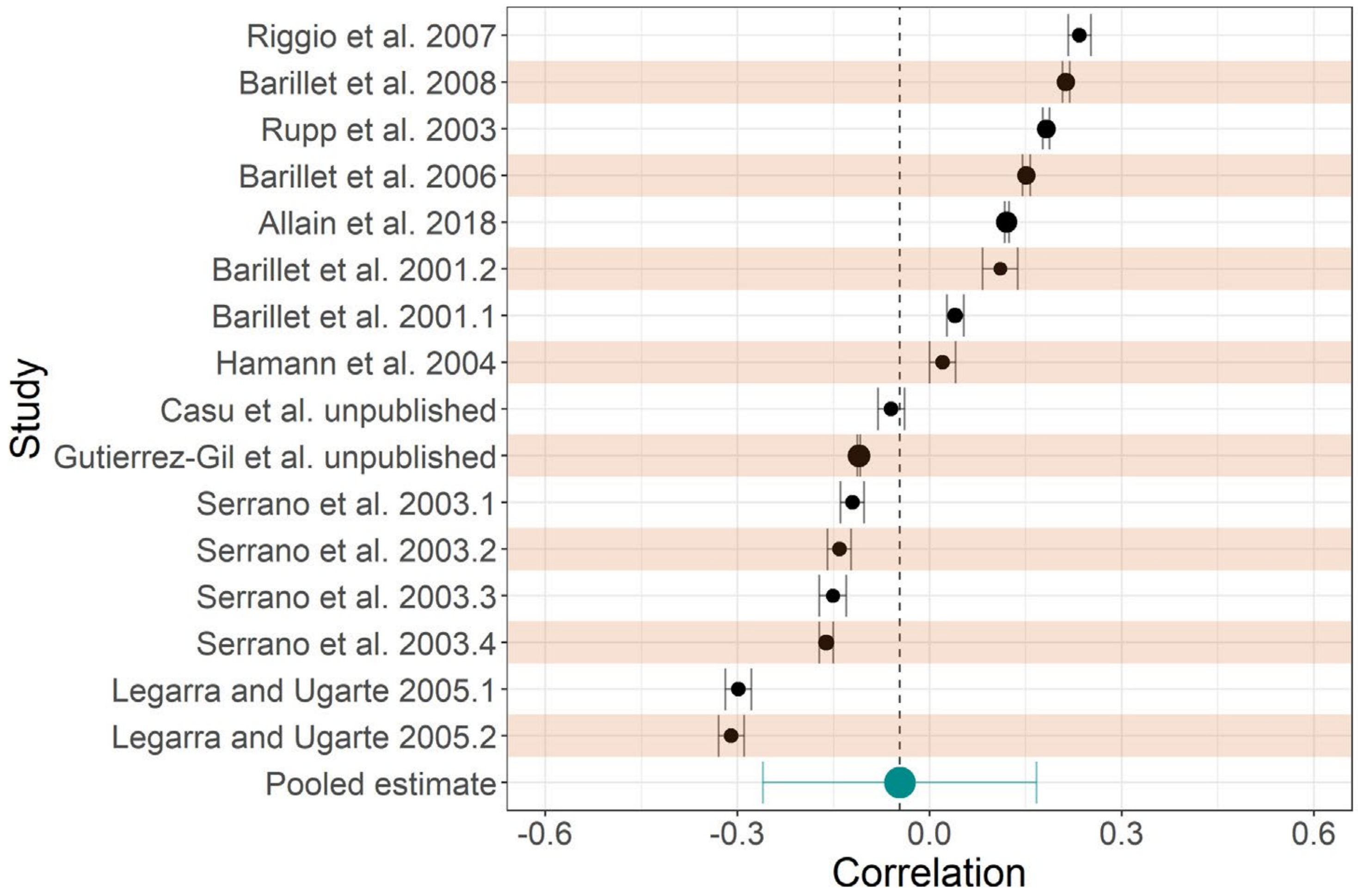


Fig. 2. Forest plot showing genetic correlation estimates between somatic cell score and milk yield in dairy sheep.

Mucha et al., 2022

Conclusions

- These differences highlight the need for breed-specific investigations to characterize the complex relationships between milk composition and mineral content. The synthesis of the minerals in milk depend several factors that include the diet and nutrition, stress and illness, hormonal levels, but also genetic factors that can be determinate the absorption, transport and metabolism

Heritability

- Composition: Low to medium heritability for both breeds
- Minerals: Medium to high heritability for both breeds

- **Genetic Correlation**

  Generally negative genetic correlations between minerals and composition but highly variable

- Need to increase the number of records to more accurate estimates

- Need of the increase research in these area to obtain better insight about the relationship between this traits → Breeding programs

Thank you for your attention