# Implementation of a routine genetic evaluation of milk coagulation properties in Italian Holstein breed

Galluzzo F[1,2], Visentin G[2], de Rezende MPG[1], van Kaam JBCHM[1], Finocchiaro R[1], Marusi M[1], Cassandro M[1,3]

*[1]ANAFIBJ, [2]University of Bologna, [3]University of Padova*

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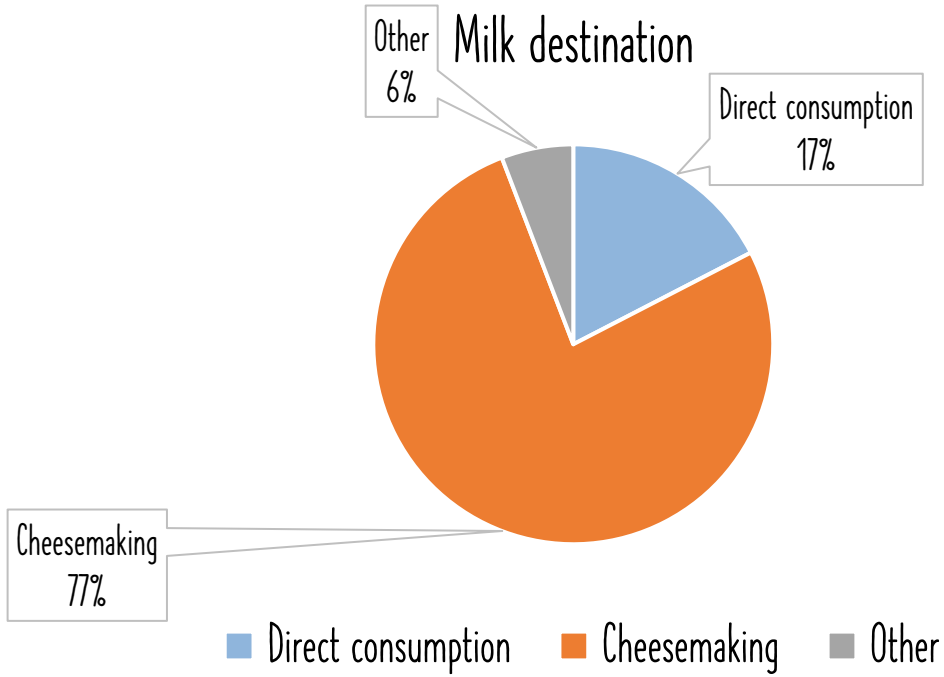
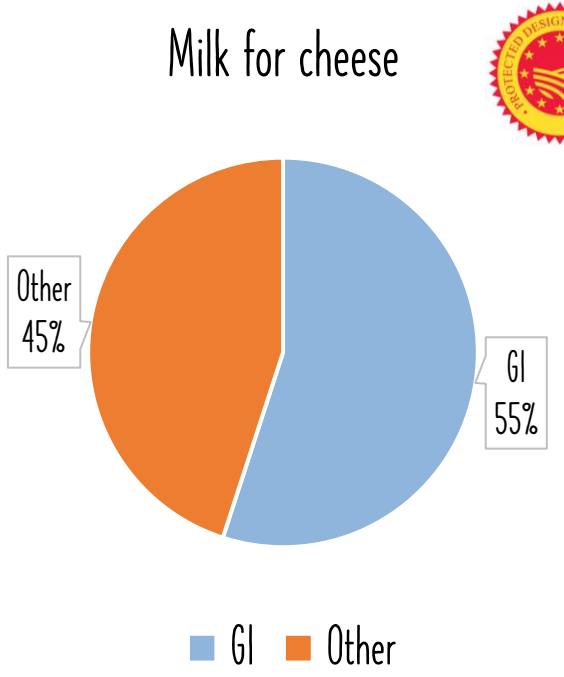
# The importance of cheesemaking in Italy




- 56 geographical indications and traditional specialties
- 2021 production value: €4.7B (+12.8% annual basis)
- 2021 export value: €2.4B (+15.4% annual basis)

*(Report ISMEA, 2022)*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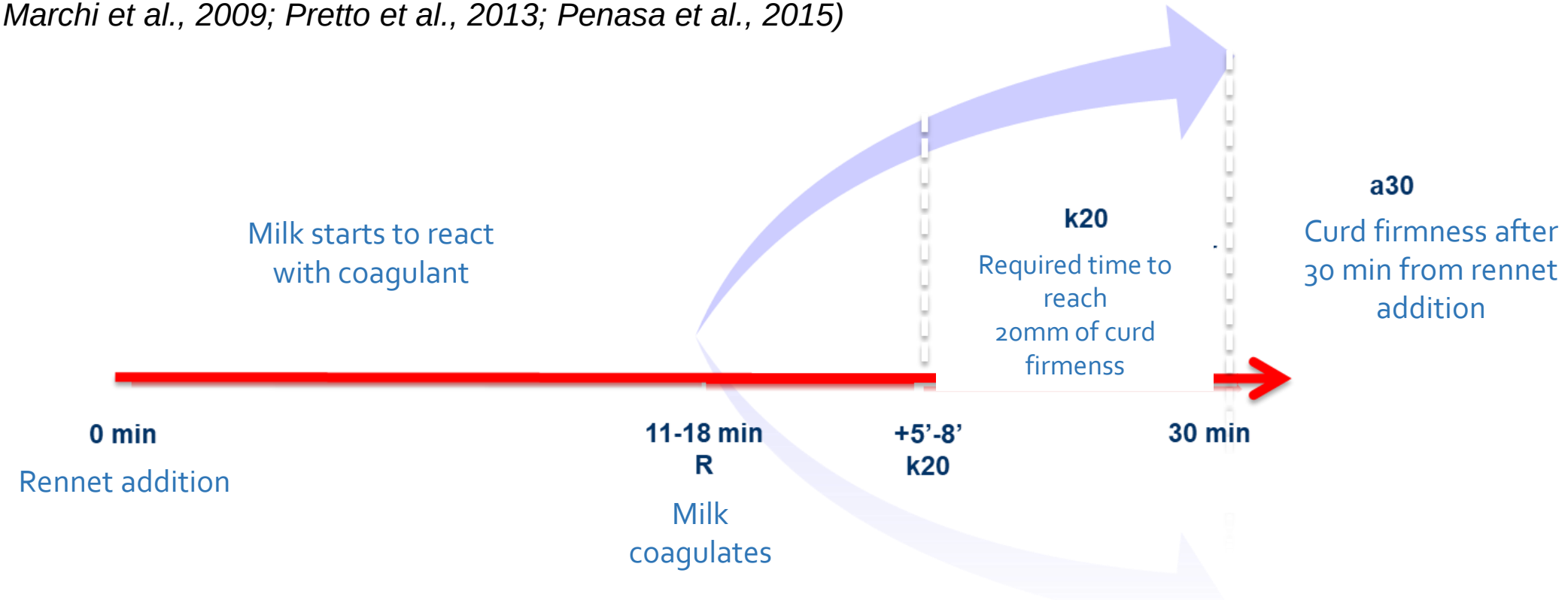
# Aims

- Study genetic aspects of milk coagulation properties (MCP) in the Italian Holstein breed
- Develop and implement a routine genetic evaluation of MCP in the Italian Holstein breed in order to identify the animals with the highest genetic potential for producing the most suitable milk for cheesemaking
- Add females to training population for the studied traits

# What are MCP?

MCP traits have been already described and analyzed in several previous studies *(Annibaldi, et al. 1977; Aleandri et al., 1989; Ikonen, 2000*; Comin et al., 2005; *Cassandro et al, 2008; De Marchi et al., 2009; Pretto et al., 2013; Penasa et al., 2015)*



# Data & data editing (1)

6.7M test-day (TD) records from 2017 onwards (*AIA, «LEO project», 2023*) – Milkoscan MIR spectra.

- Kept only records from regions that provide a consistent data flow (10/20)
- Max parity: 5
- DIM range: 5-405
- Removed obvious errors
- Min contemporaries (herd-year-season of recording): 20

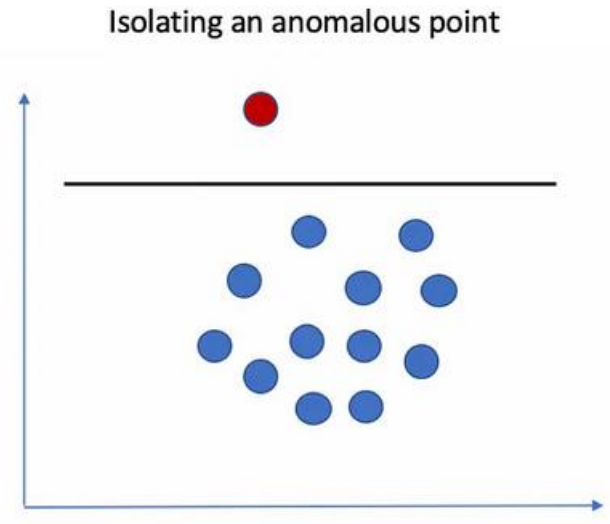
**Observations after edits: 4M**

# Data & data editing (2): isolation forest *(Pedregosa et al, 2011)*

Reference phenotypic correlations:

- RCT – A30: -0.73
- RCT – K20: 0.80
- A30 – K20: -0.79

*(Visentin et al, 2015, JDS)*




Correlations computed within herd-testday

in order to detect anomalies in lab measurements

# Descriptive statistics

| N = 4,001,769 | CAS | RCT | A30 | K20 |
|---|---|---|---|---|
| Mean | 2.72 | 25.40 | 20.73 | 7.29 |
| SD | 0.33 | 6.56 | 8.93 | 2.00 |
| CV | 12.13 | 25.83 | 43.08 | 27.44 |
| MIN | 1.06 | 5.00 | 5.00 | 1.00 |
| MAX | 6.21 | 60.00 | 60.00 | 20.00 |

- **RCT**: rennet coagulation time [minutes] – optimal range: 11-18
- **K20**: curd firming time [minutes ] – optimal range: 5-9
- **A30**: curd firmness [millimeters] – optimal range: 40-50

22% of the samples didn't coagulate before 30min
1% of them had an RCT > 45min

# Statistical model: MT repeatability linear animal model

$$CAS_{ijklmnopq} = hys_i + S_j * Yk + DIM_l * PARCm * Y_k + AGEC\_PAR_n * Y_k + a_o + pe_p + e_{ijklmnopq}$$

$$MCP_{ijklmnopqr} = hys_i + S_j * Y_k + bSCS_l + DIM_m * PARCn * Y_k + AGEC\_PAR_o * Y_k + a_p + pe_q + e_{ijklmnopqr}$$

- MCP: 3 traits (RCT, A30, K20) with the same model
- DIM: 10 classes of 30 days
- PARC (3 classes): 1, 2, 3+
- AGEC_PAR (9 classes): 1 (<24mon), 1 (24-27mon), 1 (>27mon),
  2 (<36mon), 2 (36-40mon), 2 (>40mon), 3, 4, 5
- hys & YS are relative to the recording

# Variance components

Software: THRGIBBS1F90 *(Misztal et al, 2014)*
Obs: 64,720 (150 herds)
Convergence: R package BOA *(Smith, 2007)*

Diagonal: PM (PSD)
Above diagonal: genetic correlations

| CAS | RCT | A30 | K20 |
|---|---|---|---|
| **0.33 (0.01)** | -0.04 | 0.51 | -0.67 |
| | **0.11 (0.01)** | -0.87 | 0.77 |
| | | **0.16 (0.01)** | -0.98 |
| | | | **0.15 (0.01)** |

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# Genomic validation

Multi-step genomic evaluation (EDPs as pseudo-phenotypes)

MiX99 (*MiX99 Development Team, 2022*) + GS3 (*Legarra et al, 2011*)

$$EDP_{full} = a + bDGV_{red} + e$$

Full run and reduced run (YYYY-3)

| Trait | Training | N_training | b | $r^2$ |
|---|---|---|---|---|
| CAS | Bulls | 3,276 | 1.205 | 0.452 |
| CAS | Bulls+Cows | 43,754 | 0.898 | 0.790 |
| RCT | Bulls | 3,276 | 1.359 | 0.421 |
| RCT | Bulls+Cows | 43,754 | 0.925 | 0.737 |
| A30 | Bulls | 3,276 | 1.319 | 0.478 |
| A30 | Bulls+Cows | 43,754 | 0.911 | 0.767 |
| K20 | Bulls | 3,276 | 1.246 | 0.459 |
| K20 | Bulls+Cows | 43,754 | 0.895 | 0.763 |

Average reliability increase with females:

60%

(+40,478 individuals in training population)

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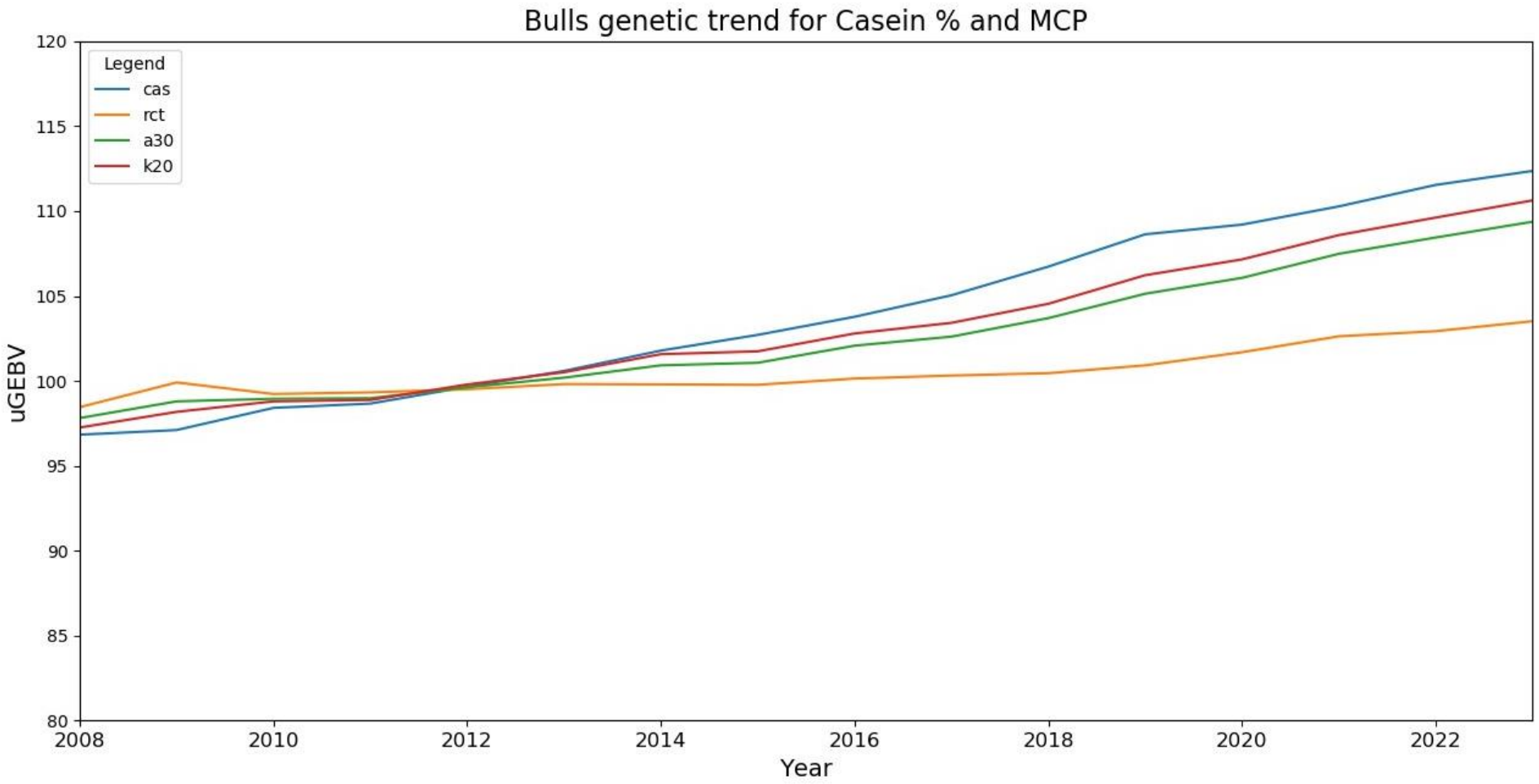
# Genetic trend (bulls by birthyear)

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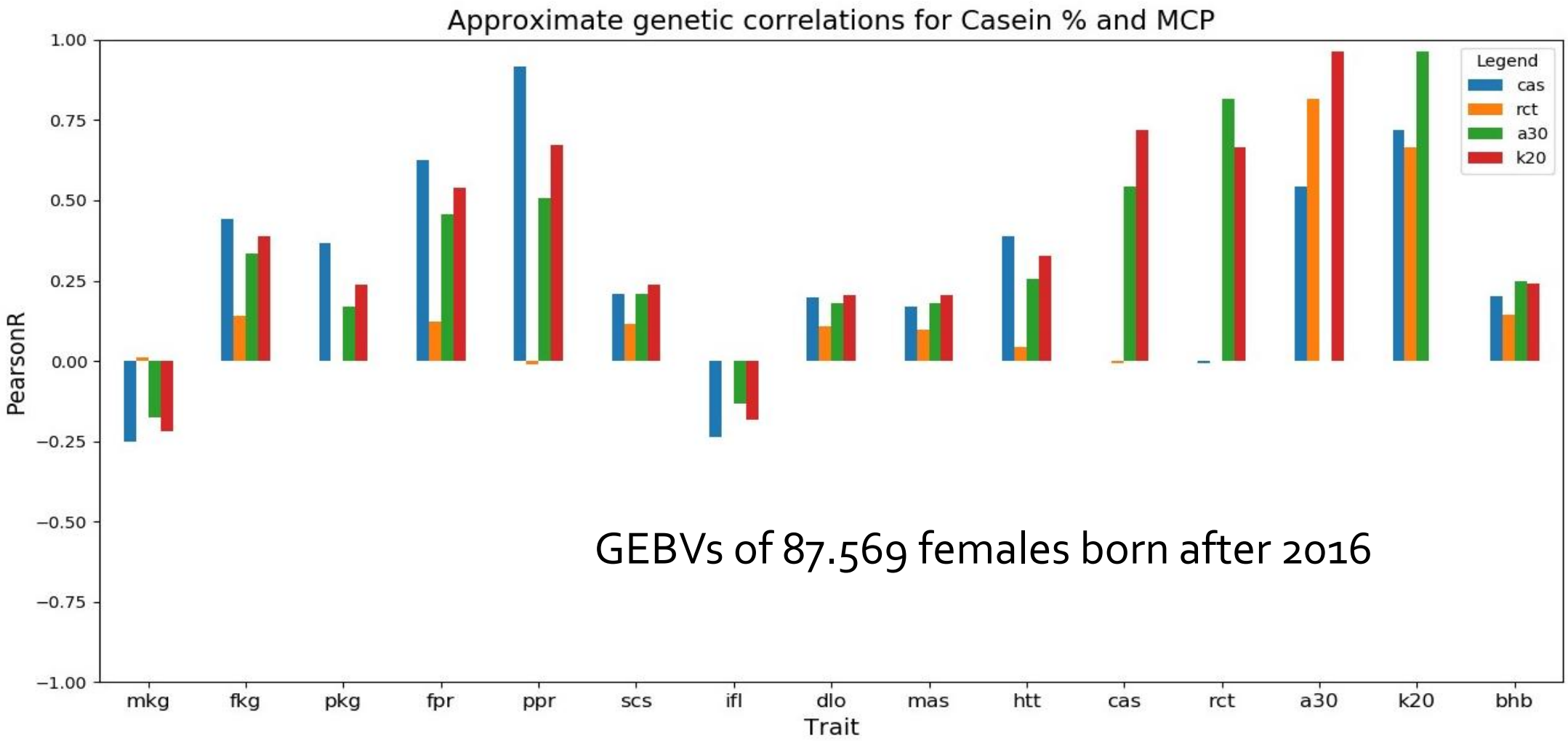
# Approximate genetic correlations




GEBVs of 87.569 females born after 2016

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# Take home massage(s)

- Selection for MCP is feasible
- No negative effects on other traits highlighted by approximate genetic correlations, except milk yield
- Indirect selection for protein kg and % was effective
- The developed model is stable enough and suitable for routine genetic evaluation
- Adding females to training population is beneficial for MCP

**These traits will be available in Italy from April '24 run (after CTC approval) with the perspective of being included in the national breeding goal for Parmigiano-Reggiano producers (ICS-PR)**

# Thank you

Ferdinando Galluzzo

ferdinandogalluzzo@anafi.it

www.anafibj.it

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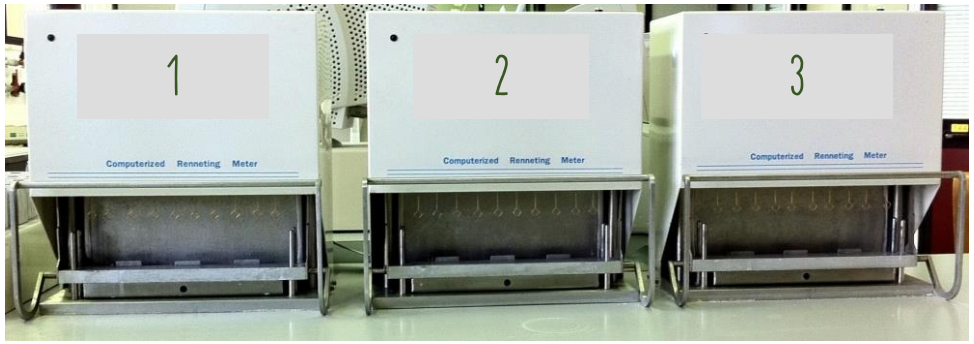
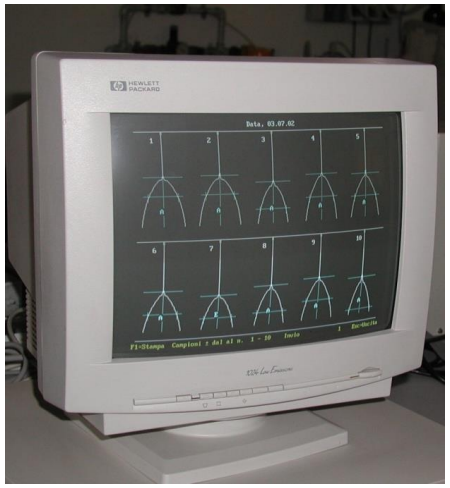
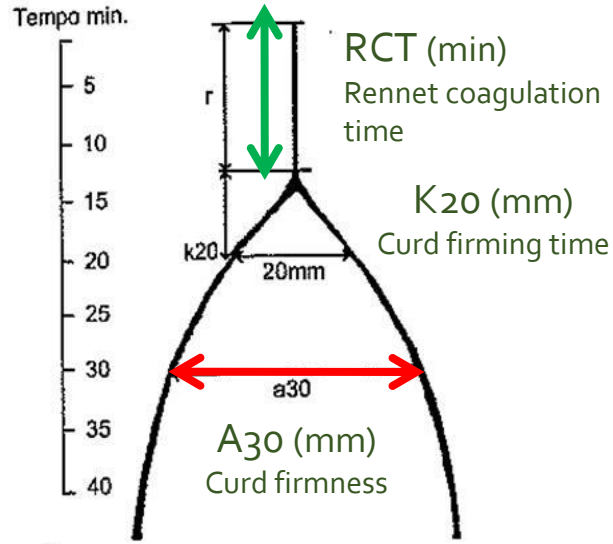
# Milk Coagulation Properties: scheme

(*Cassandro et al, ICAR 2012*)

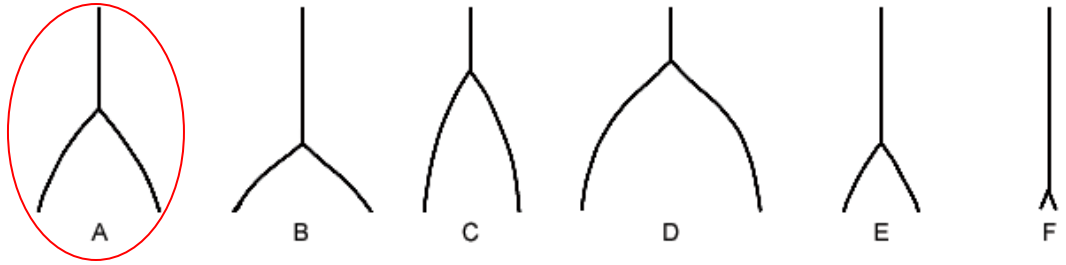
1) Lactodinamograph -LDG






**Good coagulation properties**

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