



# Selection against null-alleles in **CNS1S1** will efficiently reduce the level of free fatty acids in Norwegian goat milk

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# Outline

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1. Goat milk production in Norway
2. Free fatty acids in goat milk
3. Alpha-S1-casein genotypes
4. The Sunnlyven project:  
Effects of casein genotypes on milk production and quality
5. Gene frequency change in breeding bucks
6. Expected improvements in milk quality

# Goat milk production in Norway (1)

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- Production per year
  - 20 million litres of milk
  
- Structure
  - Farmers: 430
  - Milking goats
    - Total: 38 000
    - 85 goats per herd
    - Recorded: 85%

- Breed:  
Norwegian Dairy Goat
  - Native breed
  - Composite  
(open herd book);  
some import of semen
    - Saanen
    - French Alpine

# Goat milk production in Norway (2)

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## Products

- Brown “cheeses”
  - Whey products
  - 85% of the goat milk
  
- White cheeses
  - Increased consumption?
    - In Norway
    - Export

## Industry focus

(TINE Norwegian Dairies - the farmers' cooperative)

1. “Healthier goats”  
(Lindheim et al, EAAP 2011, Session 06-10)
  
2. Improving milk quality
  - Enhance cheese making capability
  - Reduce Free Fatty Acids

# Free fatty acids (FFA) in goat milk

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- Post milking lipolysis
- Increased levels of FFA in goat milk and cheese are associated with "bad taste"
  - Rancid
  - Consumers consider it to be the goat flavour
- High levels of FFA is a major problem in Norway
  - Highest in the summer
    - Grazing
    - Mid lactation
- Large variation between herds and between goats within herd
  - Body condition
  - Feeding
  - Genetics

# CSN1S1 (alpha-S1-casein) haplotypes

## Norwegian goats

- ❑ Ten CSN1S1 haplotypes (Hayes et al, 2006)
- ❑ Two haplotypes with a single point deletion in CSN1S1 ("null-allele")
  - Exon 12: frequency 0.72  
Unique for Norway
  - Exon 9: frequency 0.08

## Effects of null-alleles

- ❑ No production of alpha-S1-casein
- ❑ Decreased alpha-S1-casein and total protein %
- ❑ Reduced cheese making capabilities
- ❑ Decreased milk fat %
- ❑ **Increased FFA**  
*Lamberet et al, 1996*  
*Åndøy et al, 2003*  
*Grindaker et al, 2007*

# Aim of the Sunnlyven project

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1. Quantify the effects of “null-alleles” on
  - Milk production
  - Milk quality
2. Evaluate the effect of crossing French Alpine (imported semen) with Norwegian goats

# Material

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- 8 herds, 311 goats, first and second lactation
- 2 “breeds”
  - Norwegian sires (>20)
  - French Alpine sires (15)
- 3 alpha-S1-casein genotypes
  - Group 0-0: Two null-alleles
  - Group 0-1: One null-allele
  - Group 1-1: Zero null-alleles
- Records from the Goat Recording System (3 per lactation)
  - Milk per day (kg)
  - Milk content (FTIR spectrum)



Group 0-0: Two null-alleles  
Group 0-1: One null-allele  
Group 1-1: Zero null-alleles

# The goats

| Breed of sire               | Genetic group |            |           | Total      |
|-----------------------------|---------------|------------|-----------|------------|
|                             | 0-0           | 0-1        | 1-1       |            |
| <b>Alpine</b> <sup>1)</sup> | 8             | 92         | 40        | <b>140</b> |
| <b>Norwegian</b>            | 95            | 53         | 23        | <b>171</b> |
| <b>Total</b>                | <b>103</b>    | <b>145</b> | <b>63</b> | <b>311</b> |

1) One of the Alpine bucks were heterozygous for the Exon 9 deletion

# Analysis of variance

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## Measurements per goat per milk recording

- Milk per day (kg)
- Dry matter content (%)
  - Protein (%)
  - Fat (%)
  - Lactose (%)
- Dry matter per day (gram)
- FFA (mmol/litre)

## Fixed effects

- Herd (8)
- Genetic group (3)
- Breed of sire (2)
- Lactation number (2)
- Calendar month (11)
- Month of lactation (8)
- Genetic group x Month of lactation (24)

# Effect of genetic group (LS-Means)

Group 0-0: Two null-alleles  
Group 0-1: One null-allele  
Group 1-1: Zero null-alleles

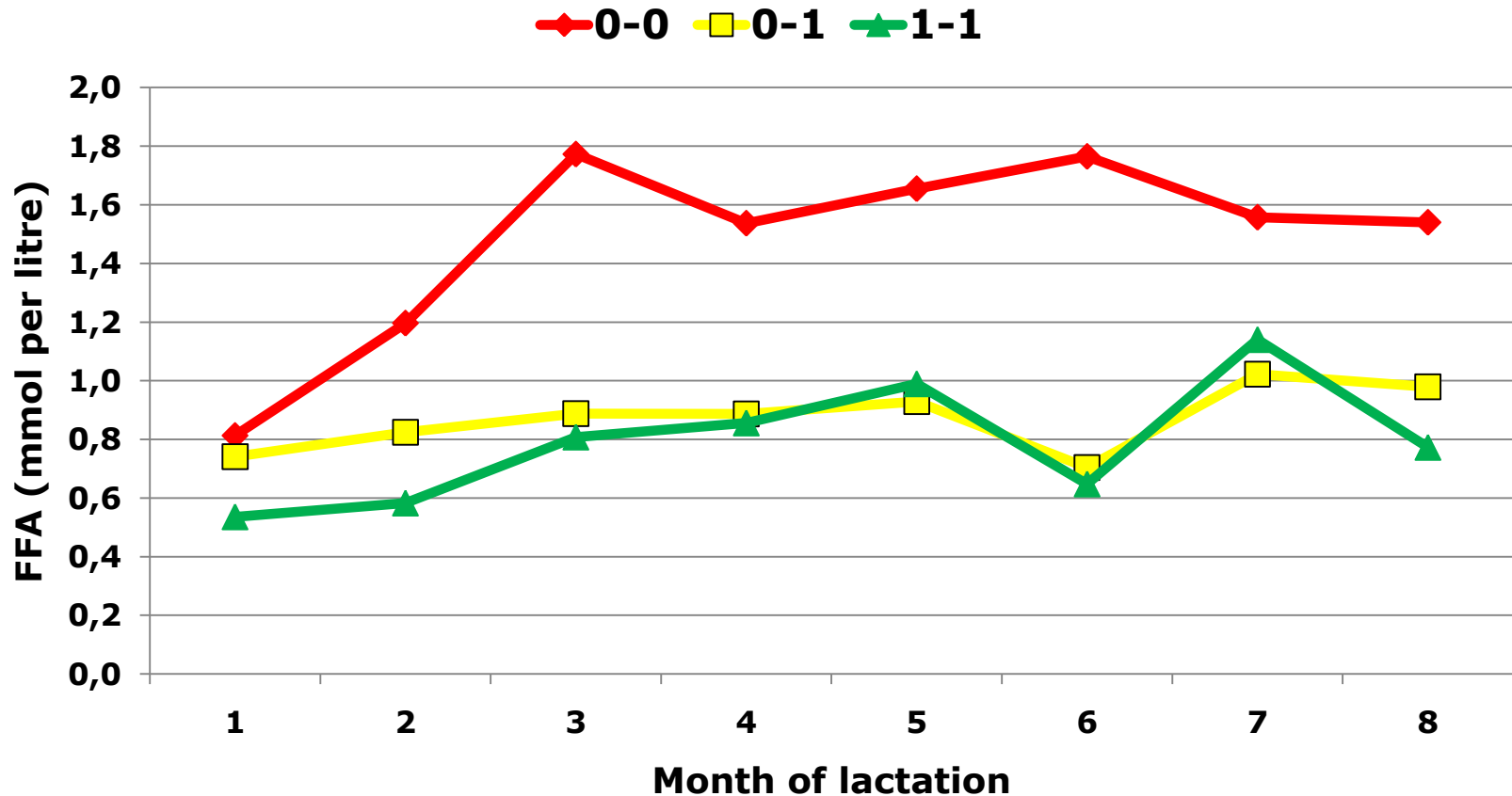
|                    | Genetic group |                      |            |                     |            |
|--------------------|---------------|----------------------|------------|---------------------|------------|
|                    | <b>0-0</b>    | ←Diff.→              | <b>0-1</b> | ←Diff.→             | <b>1-1</b> |
| Milk (kg/day)      | 2.61          | -0.12 <sup>***</sup> | 2.49       | 0.04                | 2.53       |
| Dry matter (%)     | 11.76         | 0.25 <sup>***</sup>  | 12.01      | 0.17 <sup>**</sup>  | 12.18      |
| Protein (%)        | 3.16          | 0.06 <sup>***</sup>  | 3.22       | 0.05 <sup>***</sup> | 3.27       |
| Fat (%)            | 4.23          | 0.16 <sup>**</sup>   | 4.39       | 0.08                | 4.47       |
| Lactose (%)        | 4.37          | 0.04 <sup>**</sup>   | 4.41       | 0.04 <sup>**</sup>  | 4.45       |
| Dry matter (g/day) | 304           | -7                   | 297        | 9 <sup>*</sup>      | 306        |
| FFA (mmol/litre)   | 1.39          | 0.55 <sup>***</sup>  | 0.84       | -0.02               | 0.86       |

\* P<0.05 ; \*\* P<0.01 ; \*\*\* P<0.001

# FFA throughout lactation

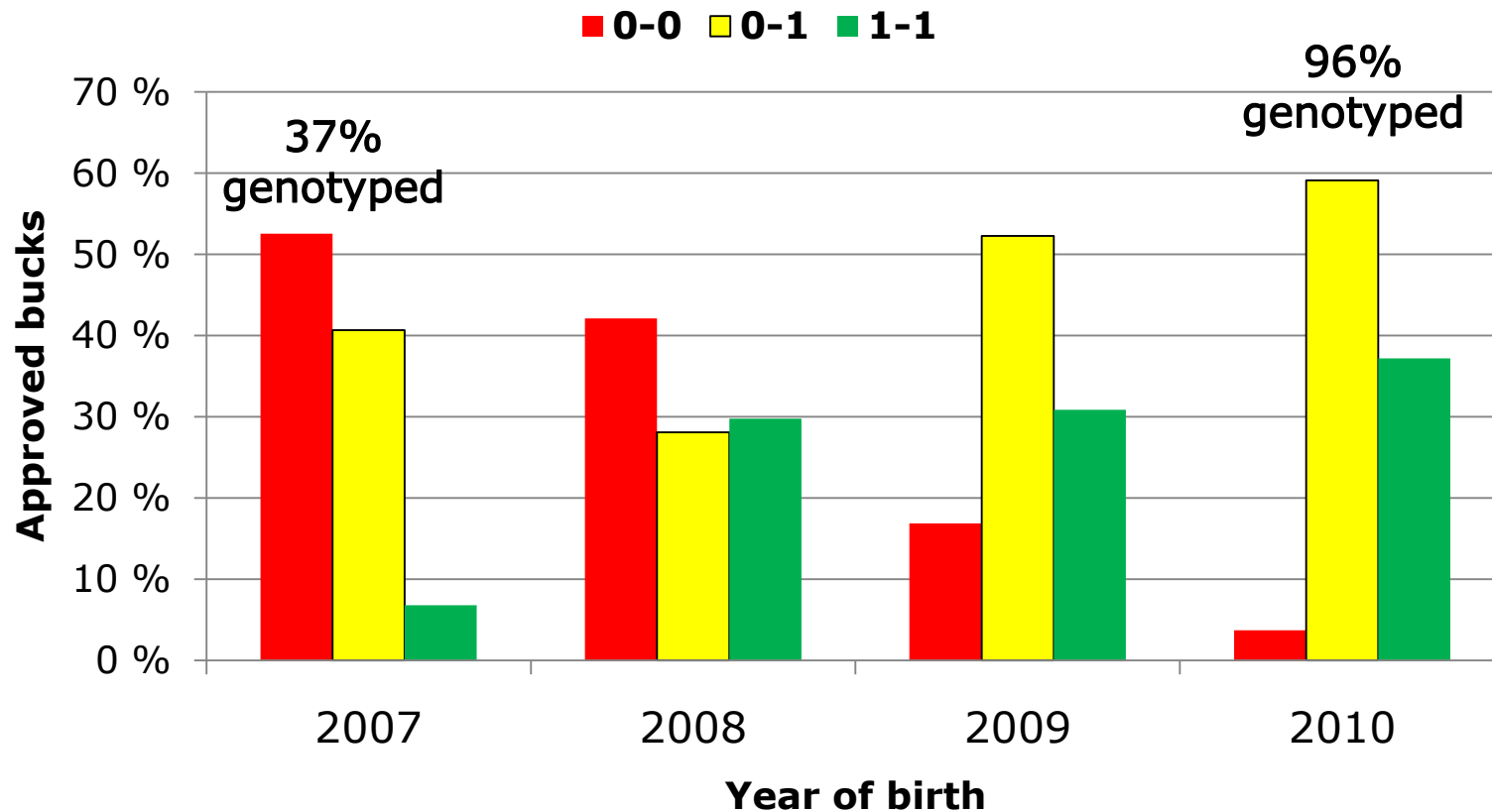
Group 0-0: Two null-alleles  
Group 0-1: One null-allele  
Group 1-1: Zero null-alleles

(LS-Means)



# Genotypes for 1/2 year old bucks approved for breeding

Group 0-0: Two null-alleles  
Group 0-1: One null-allele  
Group 1-1: Zero null-alleles



# Summing up

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1. Norwegian goat population:  
60-70% of the goats have been homozygous for the null-alleles of the alpha-S1-casein gene
2. Homozygous null-allele goats are predisposed for elevated levels of FFA from mid lactation
3. In five years time nearly all of the homozygous null-allele goats will be history in most of the herds
4. Due to changes in gene frequency the problems with FFA should have decreased substantially
5. Inadequate feeding and management may still cause FFA problems

**Thank you for your attention!**

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