Effect of grassland management in organic and conventional farming systems on bovine milk quality - a field study

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Objective

OrgMilk – A field study in Middel Norway

Gain knowledge about the effect of grassland system and production system on bovine milk quality.

Literature: Milk composition

Red clover-grass silage increases n-3 FA and PUFA compared to white clover-grass silage

Steinshamn & Thuen, 2008

Polyphenol oxidase from red clover reduces lipolysis and hydrogenation in the rumen

Lee *et al*., 2009

Red clover results in high concentrations of equol

Hoikkala *et al*., 2007

Botanical diverse herbage increases CLA compared to pure grass

Grazing increases CLA compared to preserved forage

Leiber *et al*. 2005

Lourenco *et al*. 2007

Literature: Milk composition

Organic milk contains more PUFA and n-3 FA than conventional milk

Ellis *et al*., 2006

Organic summer milk contains more PUFA, ALA, VA, CLA, n-3 FA, α-tocopherol and β-caroten then conventional summer milk

Organic winter milk contains more SFA and ALA (tendency) then conventional winter milk

Butler *et al*., 2008

Hypothesis 1

We assume lower feed energy level and higher content of legumes and native species on organic farms compared to conventional farms:

Organic milk produced on forage from botanical diverse long-term grassland has

- lower proportions of n-3 FA, VA, CLA,
- higher concentrations of α-tocopherol and β-carotene, and
- lower concentrations of phytoestrogens

than organic milk produced on forage from clover rich short-term grassland.

Hypothesis 2

Organic milk has higher

- proportions of n-3 FA, VA,
- content of α-tocopherol, β-carotene and
- phytoestrogens

than conventional milk.

OrgMilk – Experimental design

Field study

- 32 farms in Middle Norway
- In 2007-2008

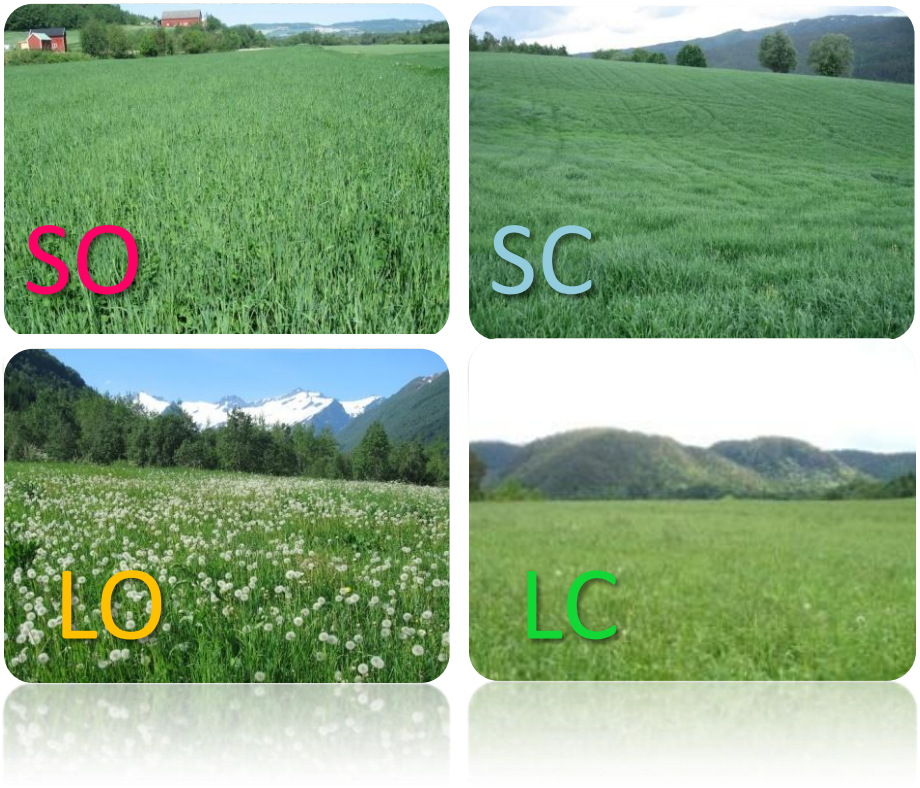
Data collection

- Feed samples and tanker milk samples every second month
- Interviews
- Botanical analysis
- Norwegian dairy herd recording system
- Preliminary results 2007

OrgMilk - Experimental design

Farm groups

- 9 **S**hort-term grassl. – **O**rganic
- 9 **S**hort-term grassl. – **C**onven.
- 7 **L**ong-term grassl. – **O**rganic
- 7 **L**ong-term grassl. – **C**onv.



OrgMilk – Statistical analysis

Model

$Y_{ijklm} = \mu + G_i + P(G)_j + M_k + rF(G,P)_l + rT(G)_m + e_{ijklm}$

G	effect of grassland system
P(G)	effect of production system within grassland system
M	effect of month
rF(G,P)	random effect of farm within G and P
rT (G)	random effect of farm pair within G

Repeated observations of M

Contrasts

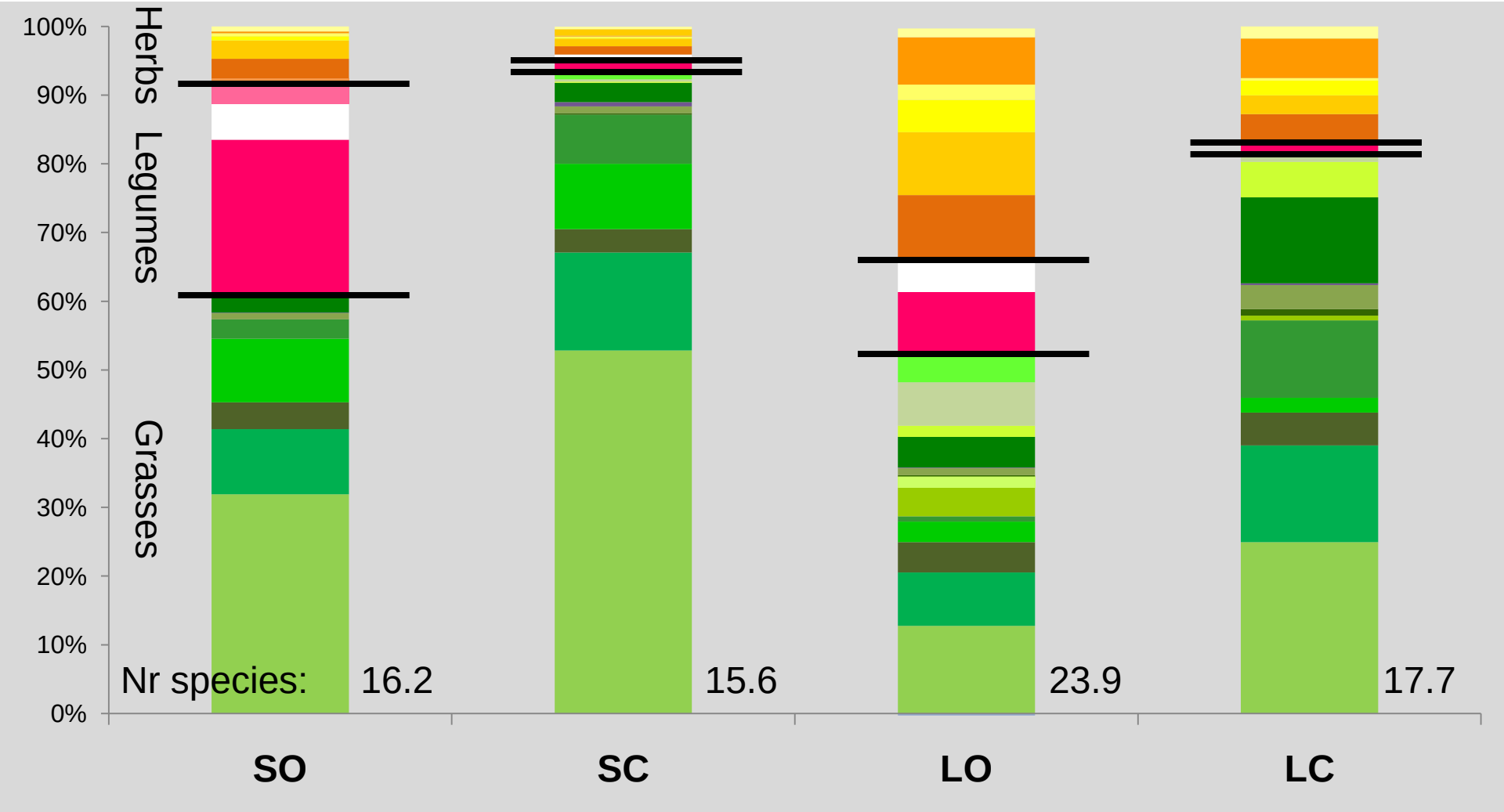
S/L	short-term/long-term G
O/C	organic/conventional P
S/W	summer/winter

OrgMilk – Farm details

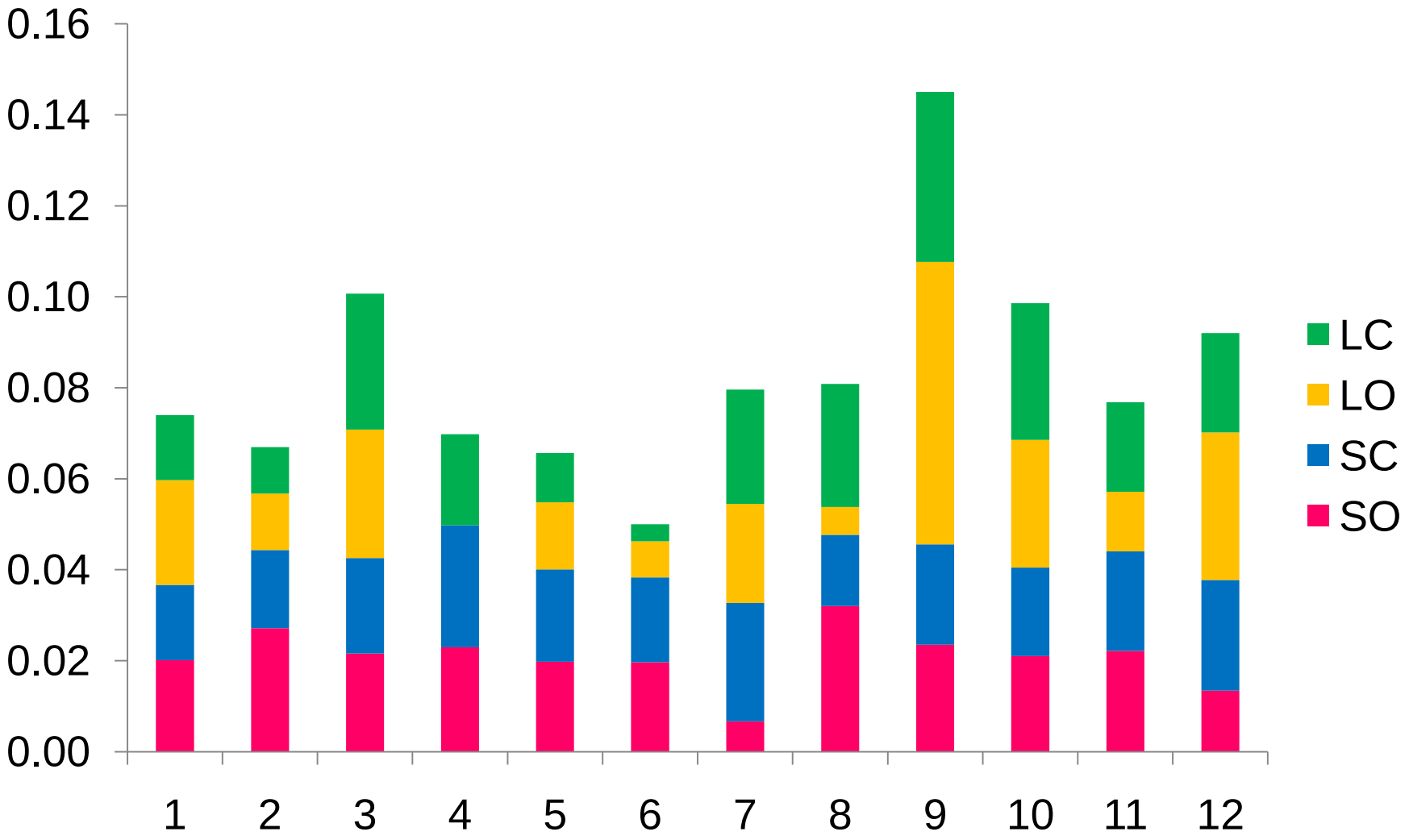
	SO	SC	LO	LC
Farm area, ha	41.2	35.2	32.4	22.3
Herd size	24.5	22.0	15.0	18.7
Altitude, m a.s.l.	68	62	**106**	**141**
Forage area proportion	0.86	0.81	**0.99**	**1.00**
Grassland age, years	2.9	2.8	**11.4**	**9.9**
Date first cut	12/06	11/06	**22/06**	**18/06**
Normal grazing period	11/05-28/09	24/05-25/09	25/05-04/10	27/05-16/09
Manure, tons/ha	27	33	33	**57**
Fertilizer, kg/ha	0	**590**	0	**507**

OrgMilk - Preliminary results 2007

Botanical composition before 1st cut 2007 (Dry weight rank method)



OrgMilk - Calving pattern (relative per month)



OrgMilk - Winter forage quality

	SO	SC	LO	LC	Sign.
Forage intake proportion (DM)	**0.65**	0.60	**0.67**	0.56	O/C*
Concentrate intake, kg DM	4.6	**5.4**	3.6	**6.0**	O/C*** S/W***
BW (est.), kg	550	520	517	538	
CP, g/kg DM	135	**169**	142	**167**	O/C***
CF, g/kg DM	37.6	**46.8**	46.7	**51.2**	O/C**
NDF, g/kg DM	666	680	656	677	
NFC, g/kg DM	**244**	184	**222**	192	O/C***
NEL, MJ	5.74	5.65	5.67	5.77	
Digestible OM, g/kg DM	661	653	655	665	
In vitro digestibility, g/kg DM	822	814	809	814	

OrgMilk – Milk yield and composition

	SO	SC	LO	LC	Sign.
Yield, kg/day	21.5	**23.7**	18.4	**21.2**	S/L* O/C*
Fat, g/kg	41.3	41.4	38.9	40.8	S/L(*) O/C(*) S/W***
Protein, g/kg	**34.6**	**34.4**	32.8	33.5	S/L**
Urea, mM	4.13	**5.65**	3.79	**5.63**	O/C***
FFA, IR, meq/l	0.44	0.51	**0.55**	**0.60**	S/L*
Sensory quality, 1-5	4.9	4.9	4.9	4.9	

OrgMilk – Vitamins and Se in milk

	SO	SC	LO	LC	Sign.
α-tocopherol (vit E), mg/L	0.601	0.687	0.709	0.700	S/W***
β-carotene, mg/L	0.180	**0.213**	0.190	**0.207**	O/C**
Retinol (vit A), mg/L	0.527	0.494	0.508	0.489	S/W***
Selenium, µg/100 mL	**2.18**	1.83	**1.87**	1.66	S/L* O/C* S/W*

S/L = contrast short-term/long-term grassland system
O/C = contrast organic/conventional production system
S/W = contrast summer/winter

OrgMilk – Milk fatty acid composition

g/100 g FAME	SO	SC	LO	LC	Sign.
C16:0 PA	**30.74**	27.63	**30.84**	27.67	O/C*** S/W***
C18:1c9 OA	21.61	**25.49**	22.75	**25.46**	O/C*** S/W***
C18:1t11 VA	1.07	1.01	1.06	0.89	
C18:2c9t11 CLA	0.69	0.72	0.83	0.64	S/W***
C18:2c9,12 LA	1.85	**2.03**	1.74	**1.87**	S/L(*) O/C* S/W***
C18:3c9,12,15 ALA	**0.72**	0.57	**0.77**	0.63	S/L(*) O/C*** S/W***
C22:6 DHA	**0.10**	0.01	**0.06**	0.01	S/L* O/C***

OrgMilk – Milk fatty acid composition

g/100 g FAME	SO	SC	LO	LC	Sign.
SFA	**69.8**	66.5	**68.5**	66.9	O/C** S/W***
MUFA	26.3	**29.6**	27.4	**29.4**	O/C*** S/W***
PUFA	4.0	3.9	4.1	3.8	S/W***
n-6/n-3 FA	2.02	**3.22**	1.90	**2.71**	S/L(*) O/C***
C14 Δ9-desaturase activity	**0.077**	0.075	**0.077**	0.073	O/C* S/W**

OrgMilk – Phytoestrogens in milk

Isoflavones, µg/L	**SO**	**SC**	**LO**	**LC**	Sign.
Formononetin	**7.47**	3.81	**4.40**	3.38	S/L** O/C***
Daidzein	**5.60**	2.48	**2.91**	1.60	S/L** O/C***
Equol	**284.4**	57.3	**86.8**	50.7	S/L** O/C*** S/W**↓
Biochanin A	1.96	0.55	0.92	0.91	S/W*↓
Genistein	**4.31**	3.23	**3.50**	2.99	O/C**
Prunetin	1.55	0.74	1.51	0.96	

OrgMilk – Phytoestrogens in milk

Lignans, µg/L	SO	SC	LO	LC	Sign.
Secoisolariciresinol	9.92	9.56	10.65	10.02	S/W***↓
Matairesinol	0.63	0.74	0.89	0.80	S/W***↓
Enterolactone	**135.0**	79.5	**98.8**	76.8	O/C** S/W***↑
Enterodiol	**0.55**	0.33	**0.36**	0.28	O/C*
Coumestans, µg/L					
Coumestrol	0.76	0.10	0.46	0.31	

OrgMilk – Reviewing hypotheses

Hypothesis 1: LO:SO

Confirmed:
Less phytoestrogens

Rejected:
No differences for VA, n-3, α-tocopherol, β-carotene
More CLA (tendency)

Hypothesis 2: O:C

Confirmed:
More n-3 FA
More phytoestrogens

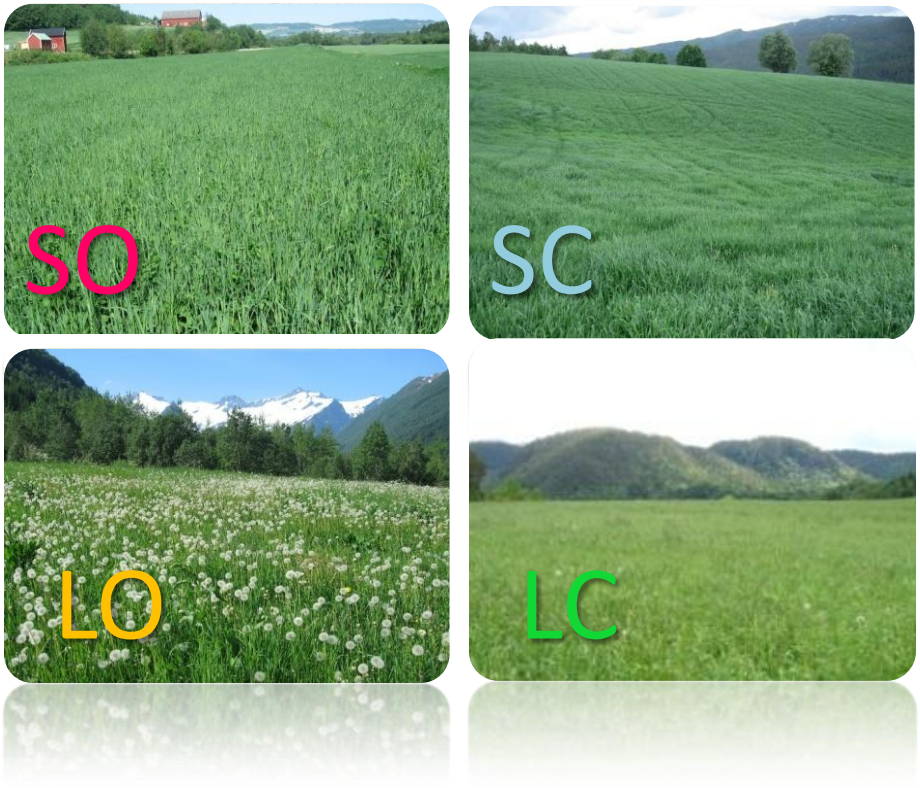
Rejected:
No differences for VA
Less β-carotene

Butler *et al*., 2008

More VA
More n-3 FA
More β-carotene

OrgMilk - Conclusions

Milk quality was more influenced by production system then grassland system.



Assumed factors

- Concentrate level
- Concentrate lipids
- Botanical composition (red clover, herbs?)

Other factors

- Grazing (summer/winter)

Thank you!

The research project was funded by Møre og Romsdal county, TINE R&D and CORE Organic funding body network.

TINE BA collected feed and milk samples in OrgMilk.