



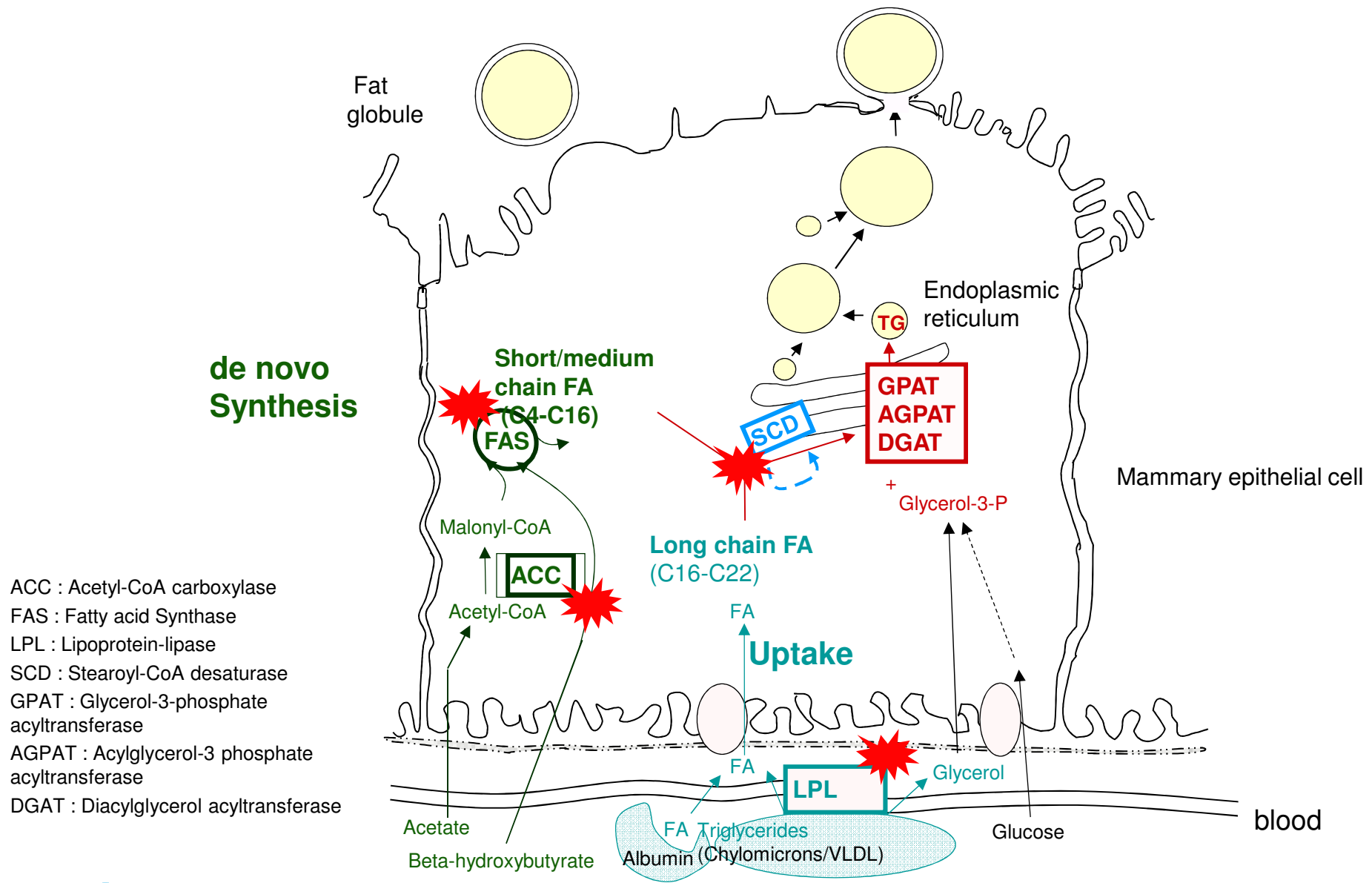
# Potential to decrease milk fat in cows fed high forage diets and associated changes in milk fatty acid composition

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# Introduction

- Fat is the most variable constituent in milk
- Milk fat concentration is typically around 4,3 %
- Milk fatty acid composition consists of:
  - Short and medium chained saturated fatty acids (4:0- 14:0, 16:0)
  - Monounsaturated fatty acids (MUFA; *cis*-9 18:1)
  - Polyunsaturated fatty acids (PUFA; *cis*-9, *trans*-11CLA)
  - *Trans*-fatty acids

# Milk fatty acid sources



- ACC : Acetyl-CoA carboxylase
- FAS : Fatty acid Synthase
- LPL : Lipoprotein-lipase
- SCD : Stearoyl-CoA desaturase
- GPAT : Glycerol-3-phosphate acyltransferase
- AGPAT : Acylglycerol-3 phosphate acyltransferase
- DGAT : Diacylglycerol acyltransferase

# Introduction

- Milk fat composition can be altered by changing the dairy cow's diet:
  - Plant oils or seeds
  - Marine oils
  - Forage source
  - Forage:concentrate-ratio
  - Rumen protected lipid supplements
- Depending on the strategy used to alter milk fatty acid composition the changes are often accompanied by a decrease in milk fat synthesis
- Milk fat is decreased on low fibre-high concentrate diets or on rations containing lipid supplements rich in polyunsaturated fatty acids

# Introduction

- **Milk fat depression, MFD**

- Biohydrogenation theory of milk fat depression; "Mammary synthesis of milk fat is inhibited by unique fatty acids that are produced as a result of the alterations in rumen biohydrogenation." Bauman and Griinari, 2001
- Decreasing milk fat offers the opportunity to repartition energy towards body tissues during early lactation
- There are few experiments examining the potential to lower milk fat synthesis and milk energy content in cows fed high forage diets under conditions relevant to Finnish milk production

# Objectives

- Examine the potential to formulate diets to lower milk fat content ca. 15% without inducing adverse effects on intake or milk yield in cows offered grass silage
- Characterise the effects on the diversity of microbial populations in the rumen
- Investigate the changes in milk fatty acid composition and lipogenic gene expression in adipose, liver and mammary tissue associated with milk fat depression in lactating cows fed high forage diets

# Materials and methods

- Experiment was conducted in the Metabolism Unit, MTT Jokioinen
- Experimental model: Finnish ayrshire dairy cows in mid lactation, 4 x 4 Latin Square with a 2 x 2 factorial arrangement of treatments and 35 d experimental periods
- Test diets were fed over 19 days → followed by washout period of 16 days
- Diets fed as total mixed rations *ad libitum*, forage:concentrate ratio 55:45, on a dry matter basis
- Treatments:
  - high (HS) or low (LS) levels of starch
  - containing 0 (C) or 30 g (O) of mixture of unsaturated fatty acids / kg diet dry matter

# Materials and methods

## Formulation of total mixed rations

Inclusion rate (g/kg dry matter)	Treatment			
	LSC	LSO	HSC	HSO
Grass silage	550	550	550	550
Rolled barley	0	0	85	77
Ground wheat	0	0	255	231.5
Sugar beet pulp	255	231.5	0	0
Barley feed	85	77	0	0
Solvent-extracted rapeseed meal	80	80	80	80
Urea	0	1.5	0	1.5
Unsaturated fatty acids	0	30	0	30
Vitamin and mineral mixture	30	30	30	30

LSC, low starch and no oil

LSO, low starch and oil supplement of 30 g/ kg diet DM

HSC, high starch and no oil

HSO, high starch and oil supplement of 30 g/ kg diet DM



# Results



# Nutrient intake

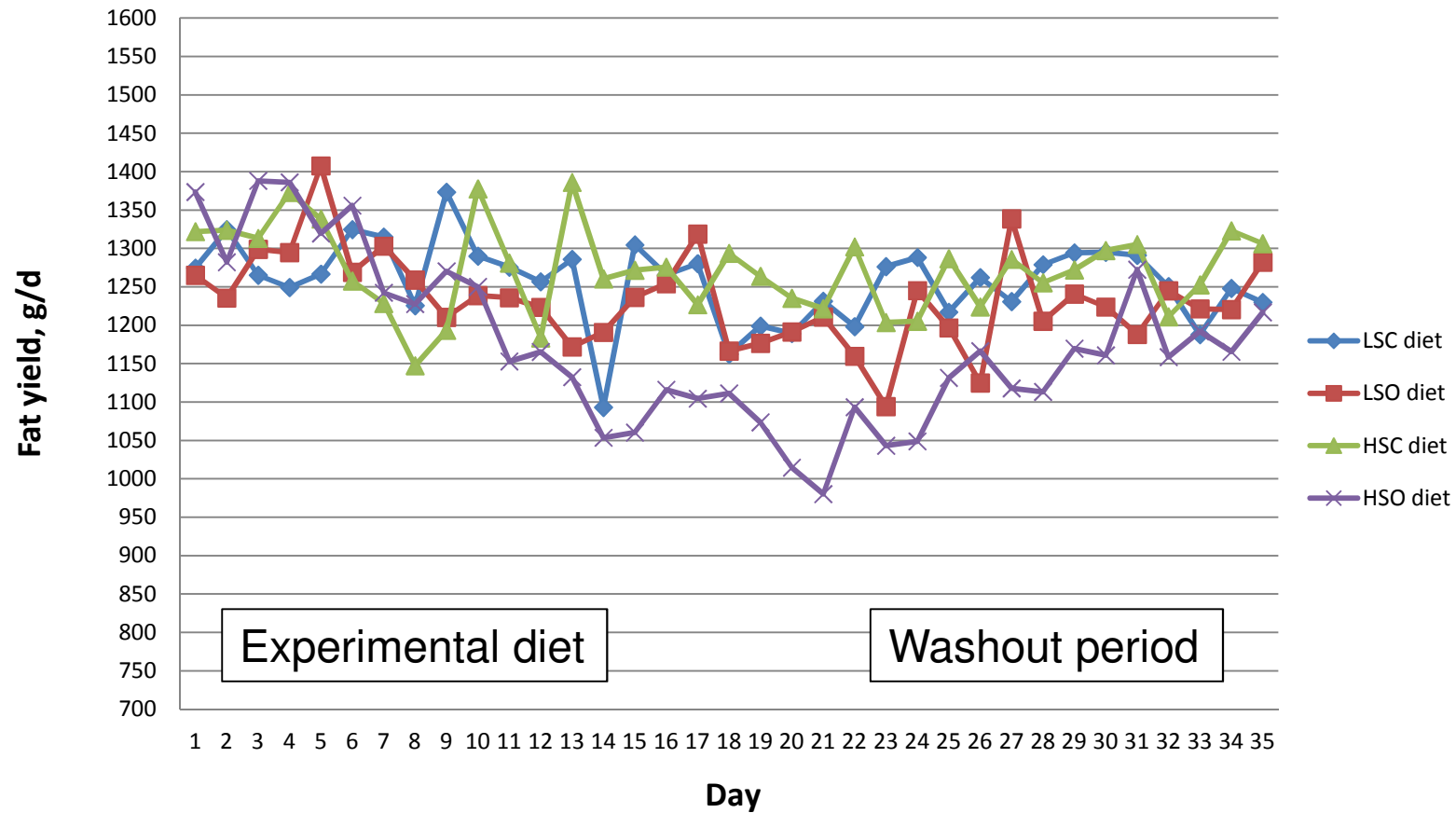
Intake	Treatment				SEM	P-value		
	LSC	LSO	HSC	HSO		Starch	Oil	Starch x Oil
<b>Silage DM, kg/d</b>	<b>13.1</b>	<b>11.9</b>	<b>13.4</b>	<b>11.9</b>	<b>0.285</b>	<b>0.362</b>	<b>&lt;0.001</b>	<b>0.56</b>
<b>Oil intake, kg/d</b>	-	<b>0.60</b>	-	<b>0.61</b>	<b>0.008</b>	<b>0.846</b>	<b>&lt;0.001</b>	<b>0.85</b>
<b>DM, kg/d</b>	<b>23.0</b>	<b>21.0</b>	<b>23.5</b>	<b>21.0</b>	<b>0.48</b>	<b>0.428</b>	<b>&lt;0.001</b>	<b>0.45</b>
CP, kg/d	3.45	3.15	3.65	3.25	0.065	0.013	<0.001	0.31
NDF, kg/d	10.4	9.22	8.71	7.66	0.205	<0.001	<0.001	0.55
Starch, kg/d	0.36	0.31	4.57	3.72	0.048	<0.001	<0.001	<0.001

# Milk yield and milk composition

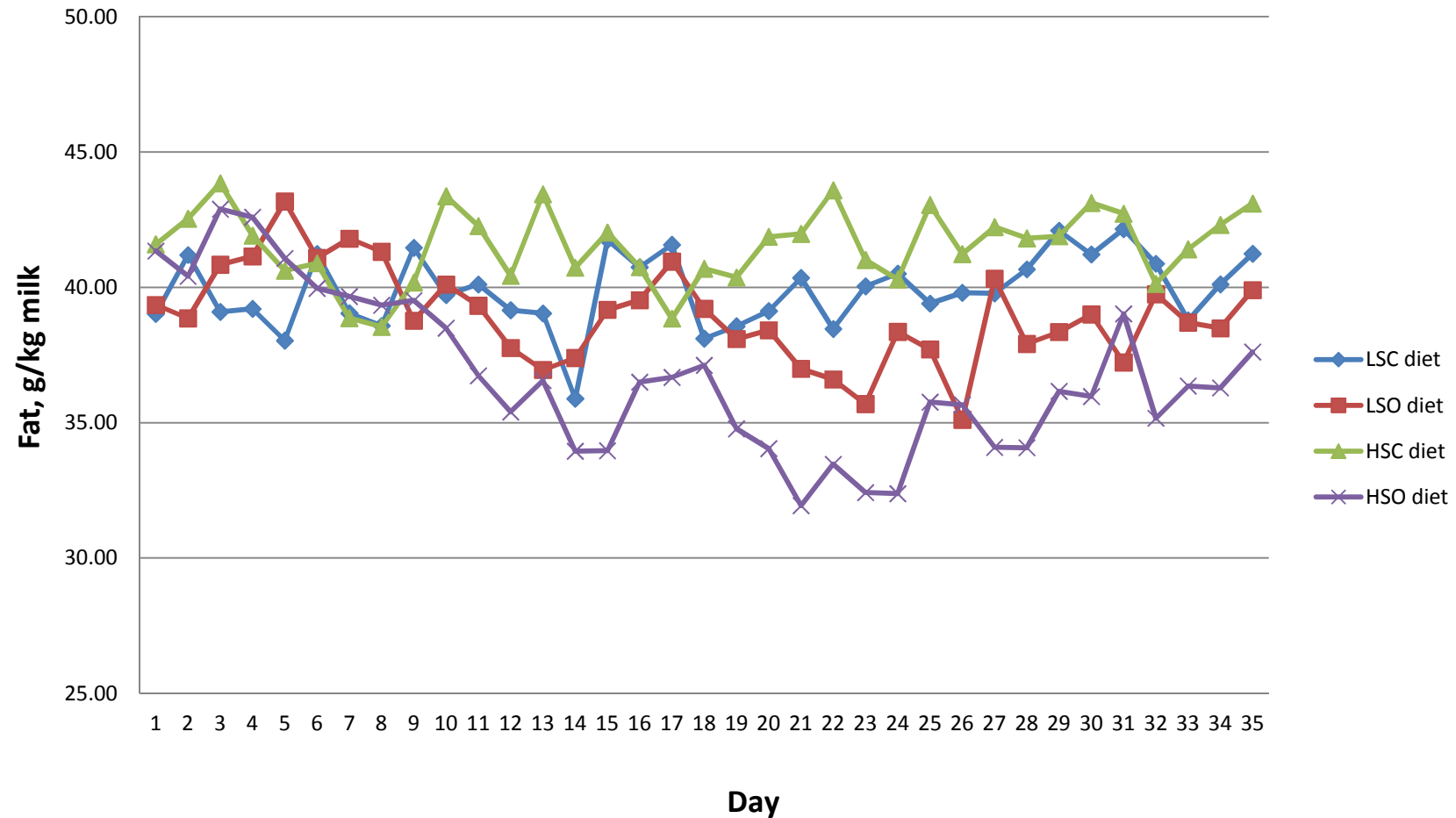
	Treatment				SEM	P-value		
	LSC	LSO	HSC	HSO		Starch	Oil	Starch x Oil
Yield								
<b>Milk, kg/d</b>	<b>30.8</b>	<b>31.8</b>	<b>31.0</b>	<b>30.5</b>	<b>1.57</b>	<b>0.54</b>	<b>0.77</b>	<b>0.45</b>
<b>Fat, g/d</b>	<b>1236</b>	<b>1250</b>	<b>1259</b>	<b>1084</b>	<b>83.1</b>	<b>0.11</b>	<b>0.08</b>	<b>&lt;0.05</b>
Protein, g/d	1014	997	1068	929	53.0	0.87	0.11	0.19
Lactose, g/d	1335	1402	1376	1359	100.9	0.99	0.65	0.45
Concentration in milk, %								
<b>Fat</b>	<b>4.00</b>	<b>3.93</b>	<b>4.06</b>	<b>3.53</b>	<b>0.116</b>	<b>0.06</b>	<b>0.01</b>	<b>0.02</b>
Protein	3.30	3.14	3.45	3.06	0.085	0.62	0.01	0.13
Lactose	4.32	4.40	4.43	4.42	0.136	0.43	0.66	0.57

Values are averages over days 14 to 17 of each experimental period.

# Milk fat yield over time



# Milk fat content over time



# Milk fatty acid composition

Milk fatty acid composition, <i>g/100g of total fatty acids</i>	Treatment				SEM	<i>P</i> -value		
	LSC	LSO	HSC	HSO		Starch	Oil	Starch x Oil
4:0	2.96	3.35	3.05	2.90	0.127	0.078	0.229	<0.05
<b>∑6:0-10:0</b>	<b>6.25</b>	<b>5.06</b>	<b>6.96</b>	<b>5.59</b>	<b>0.181</b>	<b>&lt;0.05</b>	<b>&lt;0.001</b>	<b>0.648</b>
<b>12:0</b>	<b>3.67</b>	<b>2.47</b>	<b>4.35</b>	<b>3.17</b>	<b>0.167</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.862</b>
<b>14:0</b>	<b>12.5</b>	<b>9.74</b>	<b>13.0</b>	<b>11.0</b>	<b>0.211</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.01</b>
<b>16:0</b>	<b>31.9</b>	<b>23.4</b>	<b>34.4</b>	<b>26.6</b>	<b>0.632</b>	<b>&lt;0.01</b>	<b>&lt;0.001</b>	<b>0.558</b>
18:0	9.99	11.8	8.80	6.58	0.981	<0.01	0.840	0.053
<b>18:1 <i>trans</i></b>	<b>3.75</b>	<b>10.2</b>	<b>2.47</b>	<b>15.3</b>	<b>1.338</b>	<b>0.188</b>	<b>&lt;0.001</b>	<b>&lt;0.05</b>
18:1 <i>cis</i>	15.5	17.9	14.7	11.2	1.206	0.021	0.668	<0.05
<b>∑18:1</b>	<b>19.2</b>	<b>28.1</b>	<b>17.2</b>	<b>26.5</b>	<b>0.388</b>	<b>&lt;0.01</b>	<b>&lt;0.001</b>	<b>0.586</b>

# Milk *trans* 18:1 fatty acid composition

Milk <i>trans</i> 18:1 composition, <i>g/100g of total fatty acids</i>	Treatment				SEM	<i>P</i> -value		
	LSC	LSO	HSC	HSO		Starch	Oil	Starch x Oil
<i>trans</i> -4	0.02	0.05	0.02	0.06	0.006	0.466	0.001	0.156
<i>trans</i> -5	0.02	0.04	0.02	0.05	0.006	0.248	<0.01	0.279
<i>trans</i> -6, <i>trans</i> -7 and <i>trans</i> -8	0.22	0.56	0.17	0.67	0.034	0.463	<0.001	0.078
<i>trans</i> -9	0.19	0.56	0.14	0.64	0.037	0.522	<0.001	0.088
<b><i>trans</i>-10</b>	0.20	0.52	0.15	1.98	0.671	0.334	0.158	0.302
<b><i>trans</i>-11</b>	1.85	4.88	0.91	8.99	1.142	0.214	<0.01	0.069
<i>trans</i> -12	0.25	0.99	0.20	0.96	0.047	0.395	<0.001	0.812
<i>trans</i> -13	0.44	1.22	0.35	1.11	0.077	0.252	<0.001	0.882
<i>trans</i> -15	0.29	0.74	0.27	0.50	0.035	<0.01	<0.001	<0.05
<i>trans</i> -16	0.27	0.61	0.24	0.32	0.054	<0.05	<0.01	0.052

# Milk fatty acid composition

Milk fatty acid composition, <i>g/100g of total fatty acids</i>	Treatment				SEM	<i>P</i> -value		
	LSC	LSO	HSC	HSO		Starch	Oil	Starch x Oil
18:2 <i>n</i> -6	1.16	1.11	1.14	0.97	0.078	0.097	<0.05	0.171
<b><i>cis</i>-9,<i>trans</i>-11 CLA</b>	<b>0.72</b>	<b>1.77</b>	<b>0.40</b>	<b>2.88</b>	<b>0.377</b>	<b>0.311</b>	<b>&lt;0.01</b>	<b>0.090</b>
18:3 <i>n</i> -3	0.59	0.85	0.54	0.66	0.038	0.012	0.001	0.064
18:3 <i>n</i> -6	0.017	0.011	0.018	0.006	0.0022	0.259	<0.01	0.198
$\Sigma$ SFA	<b>71.5</b>	<b>59.8</b>	<b>74.1</b>	<b>59.8</b>	<b>0.81</b>	<b>&lt;0.05</b>	<b>&lt;0.001</b>	<b>&lt;0.05</b>
$\Sigma$ MUFA	<b>23.8</b>	<b>32.6</b>	<b>22.0</b>	<b>31.5</b>	<b>0.47</b>	<b>&lt;0.01</b>	<b>&lt;0.001</b>	<b>0.379</b>
$\Sigma$ PUFA	<b>4.18</b>	<b>6.78</b>	<b>3.44</b>	<b>7.70</b>	<b>0.456</b>	<b>0.778</b>	<b>&lt;0.001</b>	<b>&lt;0.05</b>



# Conclusions

- Oil inclusion decreased DM intake, but did not have an adverse effect on milk yield
- Milk fat secretion was decreased ~12 % using a high-starch concentrate diet and moderate amounts of oil supplementation
- Data demonstrate feasibility of lowering milk energy content in cows fed high forage based diets
- Oil supplementation decreased milk fat 12:0, 14:0 and 16:0 concentrations and increased MUFA, CLA, PUFA and *trans*-fatty acid concentrations

# Thank you

- Maa- ja metsätalousministeriö, MMM
- Valio
- Raisio Oyj:n Tutkimussäätiö
- A-Rehu/Atria