Effect of feeding managements on the milk concentrations of short- and medium-chain fatty acids

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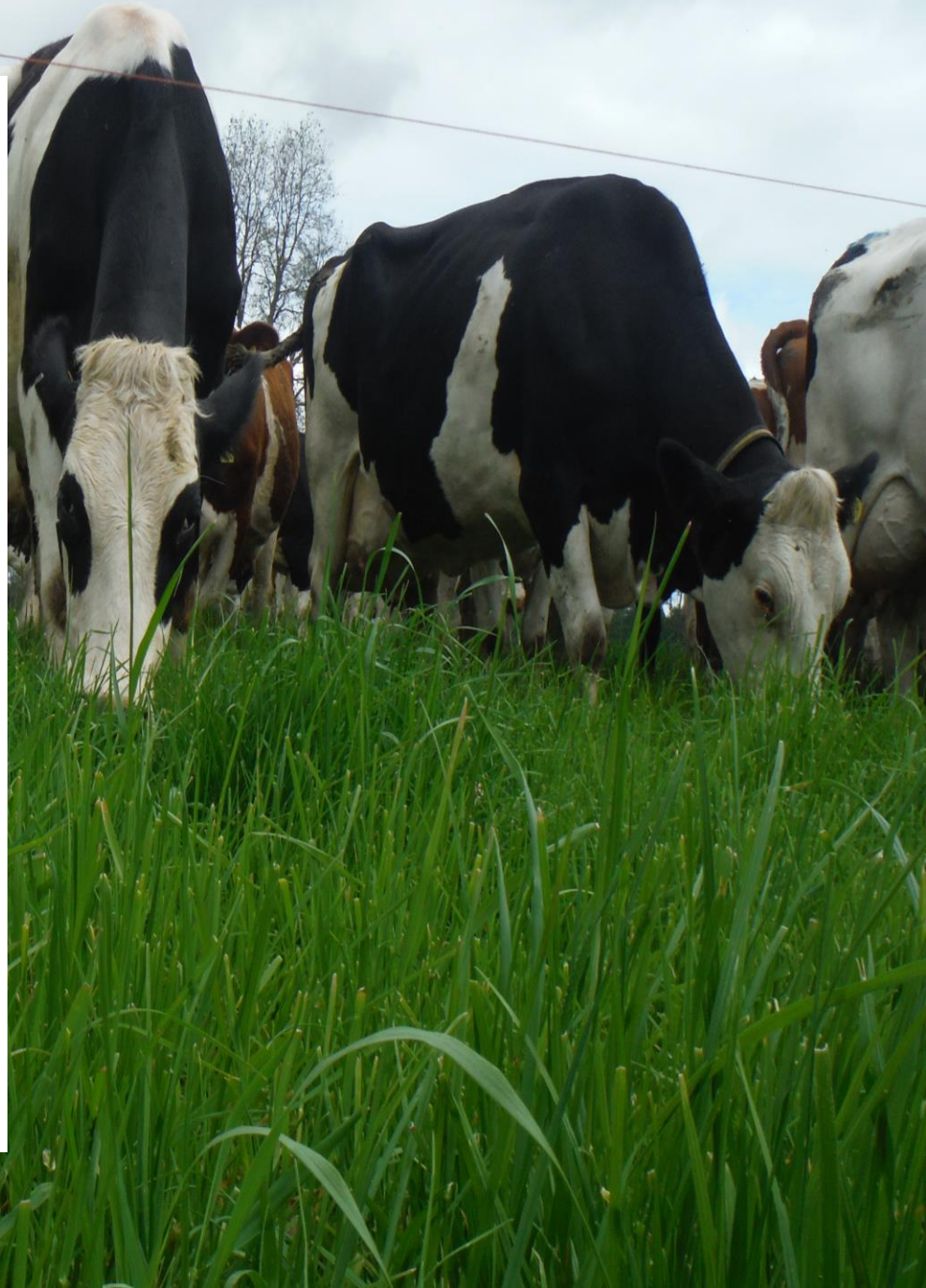
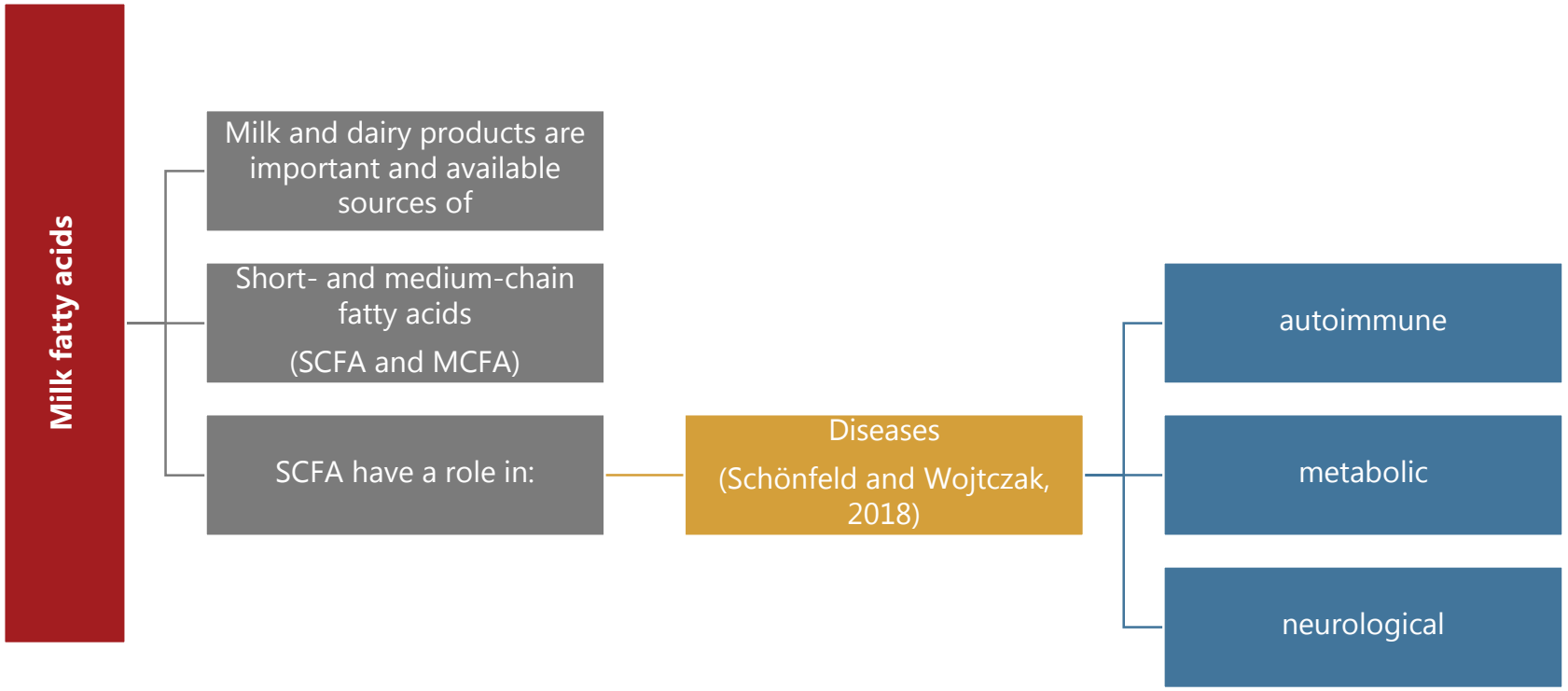
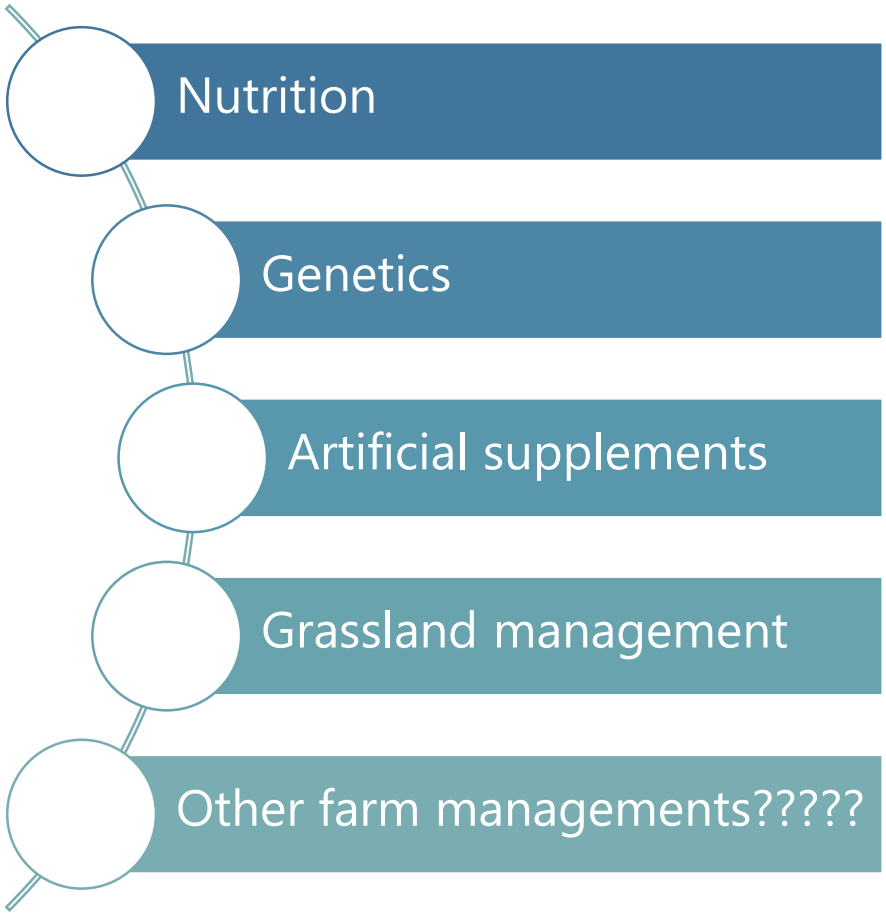


Background



Schönfeld and Wojtczak, 2018. J Lipid Res 57(6):943-954

Background : Modulation of milk fat?



Background

In Denmark

- Hein et al. (2018)
  - Differences in genetic correlations between:
    - Total fat and the monounsaturated FA, polyunsaturated FA, SCFA, and C16:0 contents between Danish Holstein and Jersey Holstein cows
  - No correlations were made between the contents of milk SCFA and MCFA and the different farm and feeding managements from each herd

Fatty acid data analysis

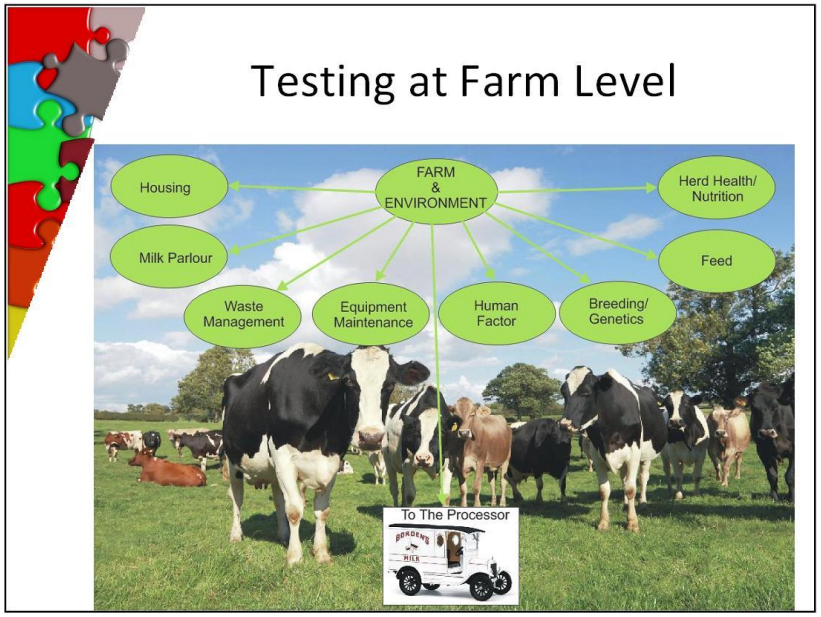
- Product authentication
  - Milk vs. non-dairy beverages (Vargas-Bello-Pérez et al., 2017)
  - Small-scale vs. large-scale cheese production (Vargas-Bello-Pérez et al., 2018)
- Can identify on-farm conditions that are affecting milk FA profiles (Mele et al., 2016)

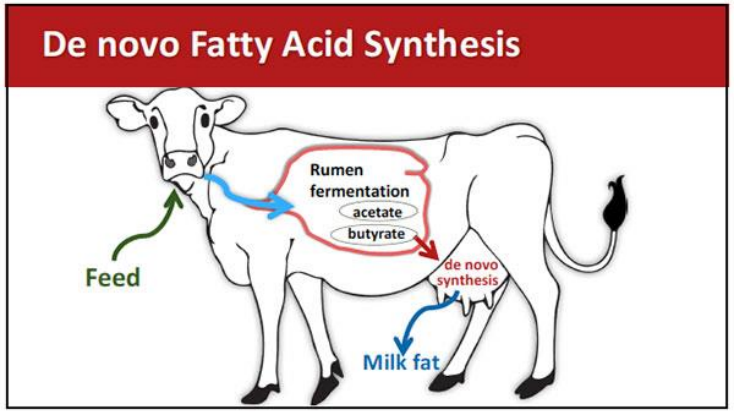
Hein et al., 2018. J Dairy Sci 101(3):2148-2157
Mele et al., 2016. J Dairy Sci 99(12):9820-9833
Vargas-Bello-Pérez et al., 2017. J Dairy Sci 100(6):4253-4257
Vargas-Bello-Pérez et al., 2018. Int Dairy J 85:280-284

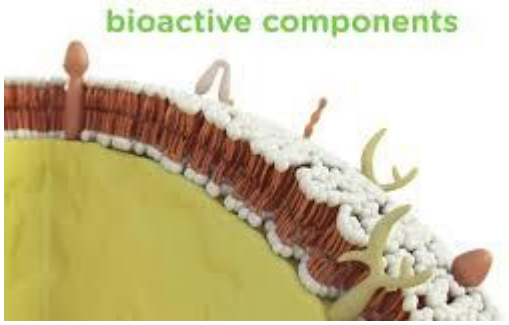
Objective

- To identify the feeding managements (amount of dietary maize and grass silages) that are responsible for production of milk with high concentration of SCFA (4 to 6 carbons) and MCFA (from 8 to 14 carbons)

Conceptual framework







Thise Mejeri

det økologiske mejeri NATURMÆLK

Methodology

- Existing data:
  - 388 milk samples
  - 7 organic farms
  - 2 seasons
  - Milk fatty acid profiles
  - Y = Farm + season + (farm × season)+Days in milk category + Fat percentage + Animal (random) + Error

Farm	Grass silage (% DM)	Maize silage (% DM)	DM intake (kg DM/d)	Somatic cell counts ($\times 10^3$/ml)
1	66	0	21	220
2	53	19	21	151
3	56	10	25	195
4	70	12	20	179
5	51	14	24	210
6	57	14	24	240
7	50	24	22	145

Average values from the previous 6 years

Mean, coefficient of variation (CV) of the mean, and standard deviation (SD) of the mean for the content of milk fat (g/100g), individual fatty acids, fatty acid groups and fatty acid indices (FA are given as proportions based on g/kg of FA; n = 388)

Traits	Mean	CV, %	SD	P5	P95
Milk fat	4.14	16.5	0.68	3.7	4.6
Saturated fatty acids					
C6:0	2.84	10.8	0.31	2.66	3.03
C8:0	1.58	13.4	0.21	1.43	1.73
C10:0	3.51	17.7	0.62	3.01	3.94
C12:0	3.89	18.8	0.73	3.34	4.41
C14.0	12.1	10.4	1.27	11.3	12.9
C15:0	1.14	15.4	0.18	1.01	1.25
C16:0	29.9	17.2	5.17	26.2	32.5
C17.0	0.62	13.9	0.09	0.56	0.67
C18:0	10.0	19.2	1.93	8.80	11.2
Monounsaturated fatty acids					
C14:1 cis-9	1.02	24.4	0.25	0.85	1.16
C16:1 cis-9	1.44	23.8	0.34	1.22	1.63
C18:1 trans11	1.70	36.2	0.62	1.33	1.95
C18:1 cis-9	19.6	17.1	3.38	17.3	21.5
Polyunsaturated fatty acids					
C18:2 cis-9, cis-12	2.17	27.7	0.60	1.65	2.56
C18:3 cis-9, cis-12, cis-15	0.90	28.2	0.25	0.71	1.05
C18:2 cis-9, trans-11	0.75	41.4	0.31	0.54	0.88
Fatty acid groups					
Others	6.74	12.9	0.86	6.20	7.15
Σ Saturated fatty acids	71.2	6.51	4.63	68.0	74.5
Σ Monounsaturated fatty acids	24.3	16.1	3.92	21.6	26.8
Σ Polyunsaturated fatty acids	4.41	23.2	1.03	3.69	5.06
Σ Short chain fatty acids (C6:0 - C10:0)	7.93	12.6	1.00	7.20	8.64
Σ Medium chain fatty acids (C12:0 - C14:0)	16.1	11.2	1.80	14.7	17.3
Σ Long chain fatty acids	36.5	15.7	5.77	32.7	40.2
Σ Trans fatty acids	2.61	36.1	0.94	2.02	3.05

P5 = 5th percentile, P95 = 95th percentile.

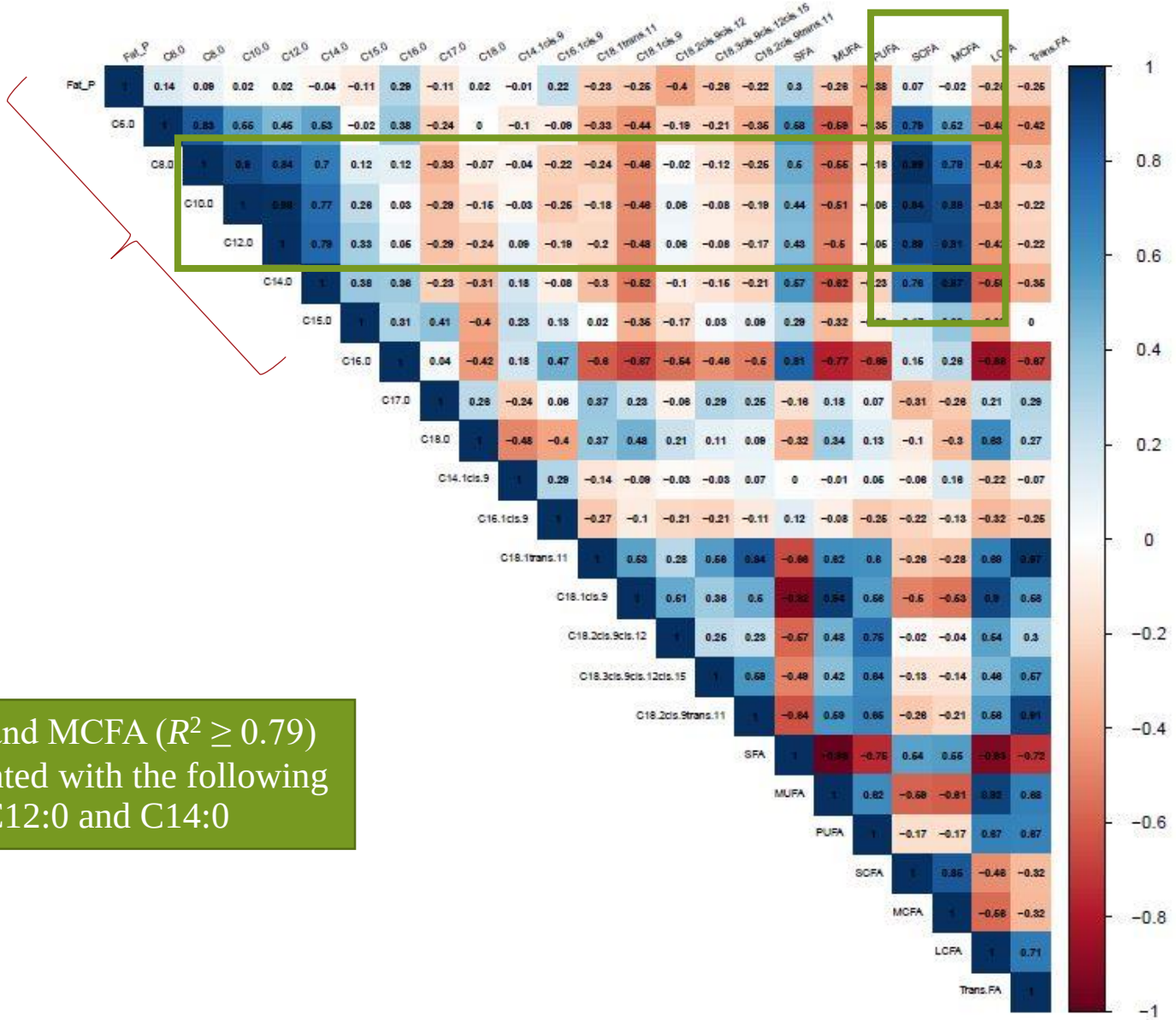
Individual fatty acids, fatty acid groups and fatty acid indices from 7 organic farms used for milk sampling (n = 388)

	Farm										
Fatty acids (g/kg of FA)	1	2	3	4	5	6	7	SEM	Farm	Season	Fat
C6:0	2.81	2.78	2.80	2.85	2.93	2.89	2.81	0.02	NS	<0.001	<0.001
C8:0	1.58^{ab}	1.53^{a}	1.55^{a}	1.60^{ab}	1.68^{b}	1.59^{ab}	1.58^{ab}	0.04	<0.05	<0.05	<0.05
C10:0	3.53^{ab}	3.33^{a}	3.41^{a}	3.58^{ab}	3.84^{b}	3.45^{ab}	3.49^{ab}	0.11	<0.01	NS	NS
C12:0	3.89^{ab}	3.67^{a}	3.81^{a}	4.00^{ab}	4.26^{b}	3.79^{ab}	3.82^{ab}	0.13	<0.01	NS	NS
C14.0	11.77^{a}	11.74^{a}	12.24^{ab}	12.37^{ab}	12.71^{b}	12.19^{ab}	11.84^{a}	0.23	<0.01	NS	NS
C15:0	1.09^{abc}	1.17	1.14^{abc}	1.19^{bc}	1.20^{c}	1.08^{ab}	1.05^{a}	0.31	<.0001	NS	NS
C16:0	27.99	29.25	30.44	30.73	30.79	31.09	28.40	1.23	NS	NS	<0.001
C17.0	0.62^{ab}	0.64^{b}	0.62^{ab}	0.64^{b}	0.63^{ab}	0.61^{ab}	0.59^{a}	0.14	<0.05	NS	<0.05
C18:0	10.69	9.92	9.68	9.83	9.87	10.42	10.19	0.49	NS	NS	NS
C14:1 cis-9	1.00	1.00	1.05	1.05	0.99	1.05	0.97	0.055	NS	NS	NS
C16:1 cis-9	1.50^{ab}	1.45^{ab}	1.48^{b}	1.46^{ab}	1.38^{ab}	1.49^{ab}	1.30^{a}	0.059	<0.05	NS	<0.001
C18:1 trans11	1.73^{ab}	1.91^{b}	1.64^{a}	1.62^{ab}	1.52^{a}	1.66^{ab}	1.82^{ab}	0.12	<0.05	NS	<0.01
C18:1 cis-9	20.95^{b}	20.02^{ab}	20.13^{ab}	19.37^{ab}	18.17^{a}	20.22^{ab}	19.26^{ab}	0.63	<0.05	NS	<0.001
C18:2 cis-9, cis-12	2.24^{ab}	1.95^{a}	2.30^{ab}	2.35^{b}	2.17^{ab}	2.11^{ab}	2.09^{ab}	0.11	<0.01	<0.05	<0.001
C18:3 cis-9, cis-12, cis-15	0.91^{ab}	1.00^{b}	0.90^{ab}	0.87^{ab}	0.82^{a}	0.83^{ab}	0.93^{ab}	0.45	<0.05	NS	<0.001
C18:2 cis-9, trans-11	0.74^{ab}	0.87^{b}	0.76^{ab}	0.72^{ab}	0.66^{a}	0.70^{ab}	0.76^{ab}	0.58	<0.05	NS	<0.001
Others	6.81	6.71	6.77	6.74	6.69	6.94	6.52	0.15	NS	<0.001	NS
Saturated fatty acids	69.70^{a}	70.31^{a}	70.75^{ab}	71.67^{ab}	73.29^{b}	71.34^{ab}	71.04^{ab}	0.78	<0.05	NS	<0.001
Monounsaturated fatty acids	25.74^{b}	25.23^{b}	24.66^{ab}	23.83^{ab}	22.51^{a}	24.49^{ab}	24.54^{ab}	0.75	<0.05	NS	<0.001
Polyunsaturated fatty acids	4.55	4.45	4.58	4.50	4.20	4.16	4.42	0.19	NS	NS	<0.001
Short chain fatty acids (C6:0 - C10:0)	38.70^{b}	37.44^{ab}	36.47^{ab}	35.76^{ab}	34.40^{a}	36.50^{ab}	37.36^{ab}	1.12	<0.05	NS	<0.001
Medium chain fatty acids (C12:0 - C14:0)	7.92^{ab}	7.64^{a}	7.76^{a}	8.04^{ab}	8.44^{b}	7.93^{ab}	7.88^{ab}	0.19	<0.05	<0.05	NS
Long chain fatty acids	15.71^{a}	15.49^{a}	16.12^{ab}	16.44^{ab}	17.06^{b}	16.04^{ab}	15.72^{a}	0.35	<.001	NS	NS
Trans fatty acids	2.65^{ab}	2.98^{b}	2.55^{ab}	2.49^{ab}	2.33^{a}	2.50^{ab}	2.79^{ab}	0.18	<0.05	NS	<0.001
C14 index	7.93	8.03	7.47	7.67	7.34	8.10	7.67	0.41	NS	<0.05	NS
C16 index	4.33	4.46	4.96	4.72	4.55	4.65	4.44	0.19	NS	NS	NS
C18 index	63.86^{a}	65.71^{ab}	66.46^{ab}	67.10^{b}	66.47^{ab}	67.60^{b}	65.55^{ab}	0.81	<0.05	<0.001	NS
CLA index	29.60^{ab}	30.39^{ab}	29.43^{a}	32.78^{b}	30.74^{ab}	29.41^{ab}	30.61^{ab}	0.92	<0.05	<0.001	NS

NS = Non significant

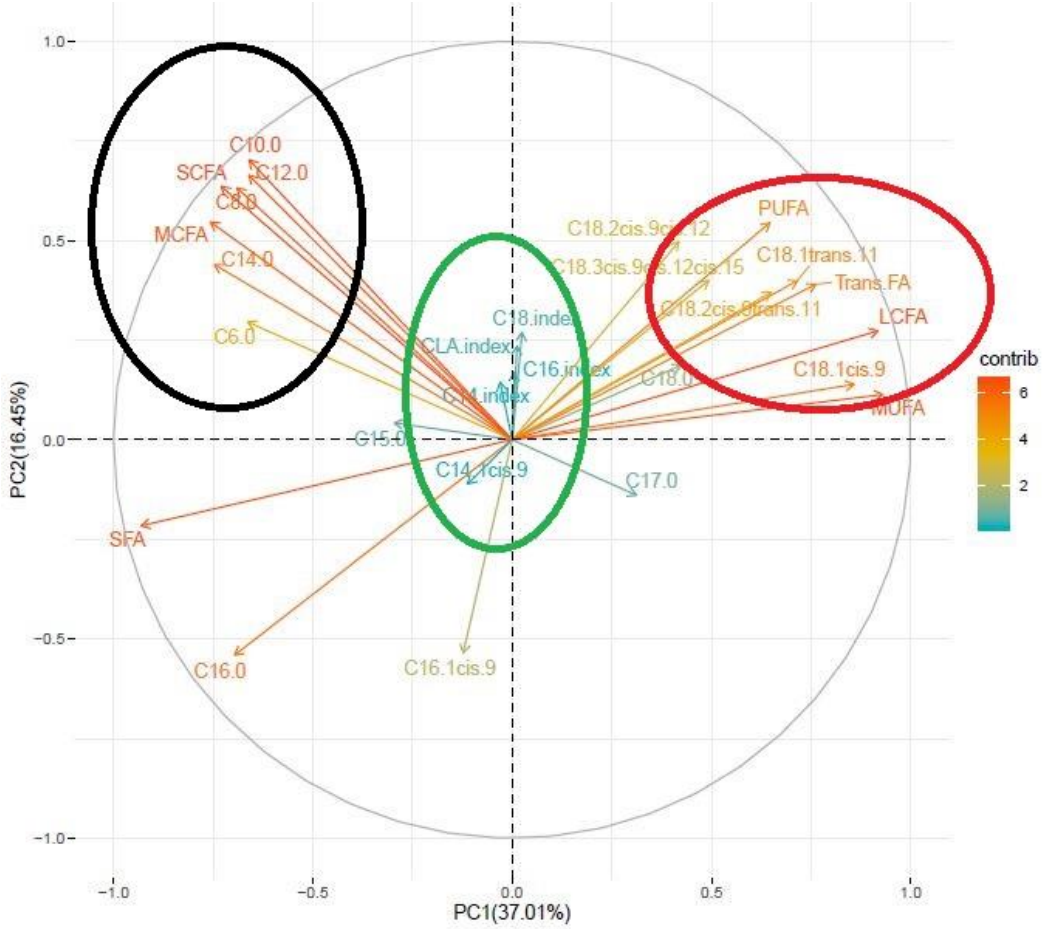
C14 index = C14:1/(C14:1 + C14:0) × 100 ; C16 index = C16:1/(C16:1 + C16:0) × 100 ; C18 index = C18:1 cis-9/(C18:1 cis-9 + C18:0) × 100 ; Conjugated linoleic acid (CLA) index = C18:2 cis-9,trans-11/(CLA cis-9,trans-11 + C18:1 trans-11) × 100.

Pearson's correlation coefficient for all individual fatty acids, fatty acid groups and fatty acid indices from 7 organic farms used for milk sampling (n = 388)

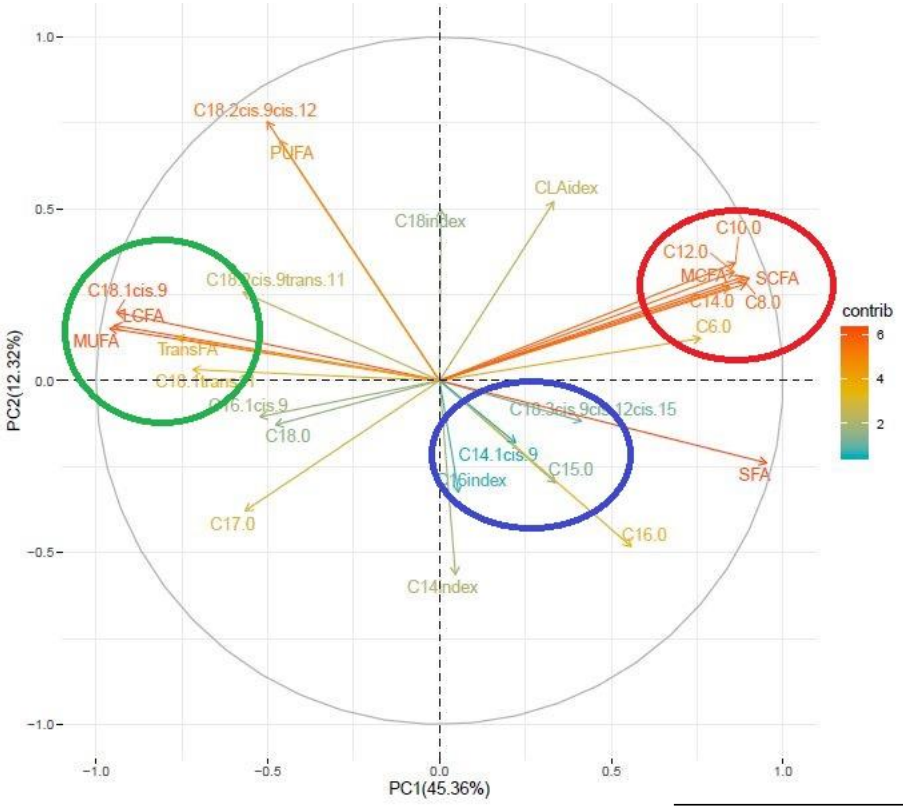


SCFA ($R^2 \geq 0.89$) and MCFA ($R^2 \geq 0.79$) were highly correlated with the following FA: C8:0, C10:0, C12:0 and C14:0

Principal components (PC) related to the milk fatty acid profile from all farms

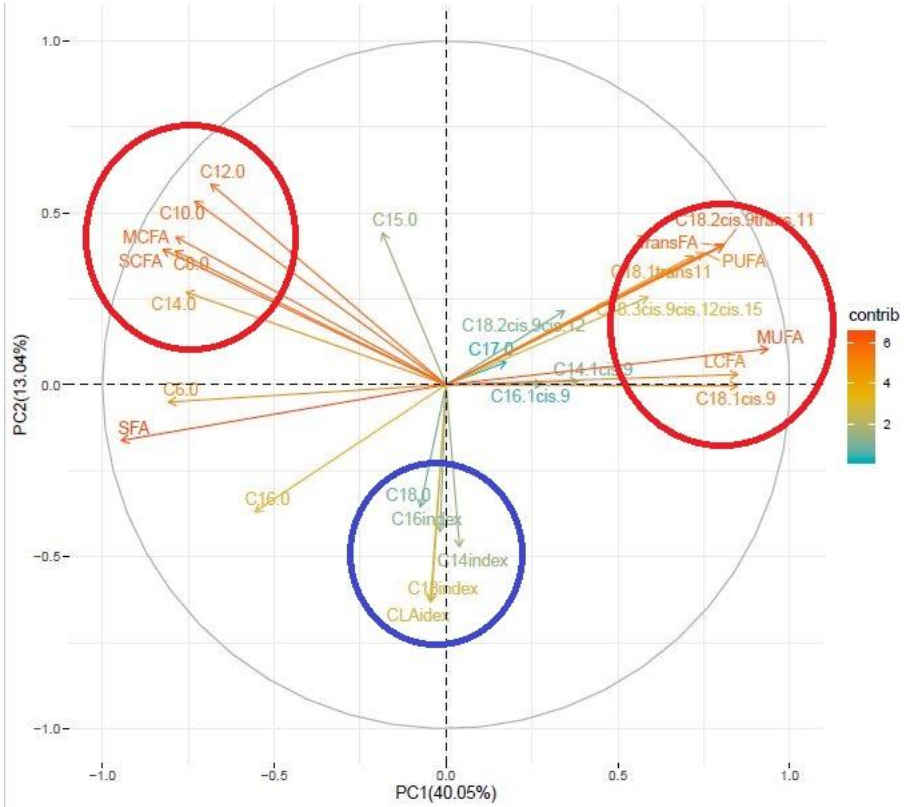


Principal components (PC) related to the milk fatty acid profile from farm 1 and 5



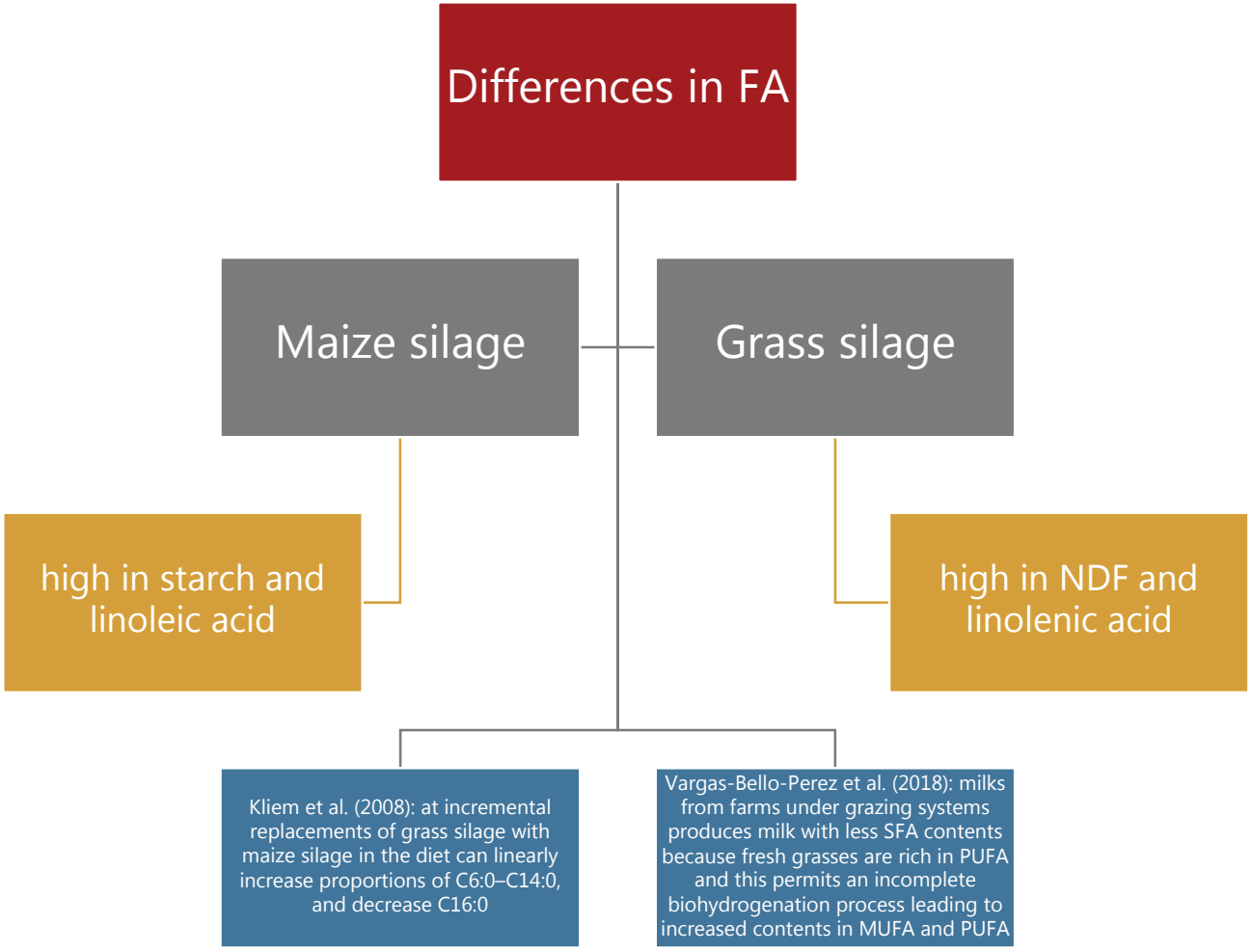
Farm 1

Farm	Grass silage (% DM)	Maize silage (% DM)
1	66	0
2	53	19
3	56	10
4	70	12
5	51	14
6	57	14
7	50	24



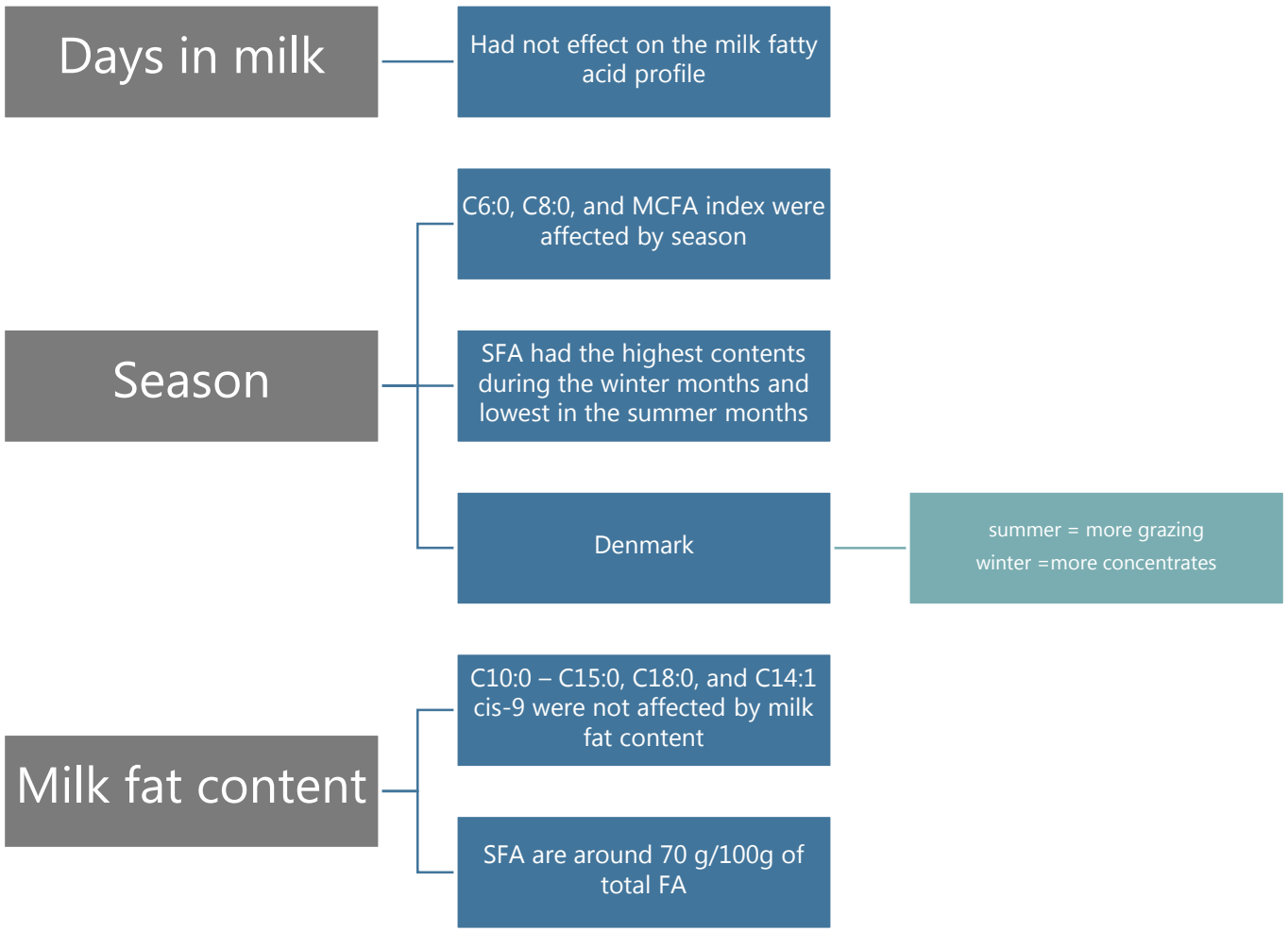
Farm 5

Overall results



Kliem et al., 2008. Animal 2(12):1850-1858
Vargas-Bello-Pérez et al., 2018. Int Dairy J 85:280-284

Overall results



General remarks

Farm	Grass silage (% DM)	Maize silage (% DM)
1	66	0
2	53	19
3	56	10
4	70	12
5	51	14
6	57	14
7	50	24

The level (% of dry matter) of dietary inclusion of grass (G) and/or maize silages (M) appeared to have an effect on SCFA (66G+no maize silage) and MCFA (51G+14M)

Increasing contents of SCFA and MCFA at the same time is very challenging due to the complexity of the cow´s lipid metabolism

It will be desirable to record individual milk yields and milk compositions together with a detailed proximate analysis of diets, silages and individual feedstuffs with their corresponding FA profile

Thank you!

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