

Genetic analysis of multivariate indices of detailed fatty acid profile determined by gas chromatography in bovine milk

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Milk fat composition



- **Key point for improving nutritional and dietary properties of milk**
- **Genetic basis**
- **Routine determination by MIR spectra**
- **Large number of variables**
- **Complex correlation pattern**

Multivariate factor analysis



The (co)variance matrix of a system could be decomposed

$$\mathbf{S} = \mathbf{B}\mathbf{B}' + \mathbf{\Psi}$$

\mathbf{S} = (Co)variance matrix of original data

\mathbf{B} = (Co)variance between original data and latent factors

$\mathbf{\Psi}$ = Specific variance matrix

Aim of the work



Use of multivariate factor analysis for

- **Studying relationships between milk yield, composition, fatty acid spectrum**
- **Estimating heritability for new derived variables**

Data



- **1,158 Brown Swiss cows**
- **85 herds**
- **Parities 1-11 (92% < 6)**
- **TD data for milk yield, fat, protein, casein and lactose percentage, SCS**
- **47 fatty acids by gas chromatography**

Multivariate factor analysis



- **Carried out on 53 variables (6 production traits + 47 FA)**
- **VARIMAX rotation**
- **Eigenvalue >1 , variance explained**
- **Loading ≥ 0.60**
- **Calculation of factor scores**

Genetic model



Bayesian linear animal model

$$\text{Factor score} = \text{DIM} + \text{parity} + \text{herd} + a + e$$

Results



- **Eleven factors able to explain 75% of original variance**
- **Kaiser MSA 0.78**
- **Simple structure**
- **Clear meaning**

Results



1. de novo FA

2. milk yield-branched FA

3. Biohydrogenation

4. long chain FA

5. short chain FA

6. milk-fat-protein

7. odd FA

8. conjugated linoleic acid

9. linoleic

10.udder health

11.vaccelenic

Factor structure



	F1
	<i>De novo</i> FA

SFA	
8:0	0.66
10:0	0.84
12:0	0.85
14:0	0.80
17:0	-0.60
MUFA	
17:1 <i>c</i> 9	-0.79
18:1 <i>c</i> 9	-0.74
Eigenvalue	0.11

	F2
	Branched FA milk yield

Milk yield, Kg	-0.63
SFA	
14:0 <i>iso</i>	0.75
15:0 <i>ante</i>	0.82
15:0 <i>iso</i>	0.75
16:0 <i>iso</i>	0.78
17:0 <i>ante</i>	0.66
MUFA	
Eigenvalue	0.11

Factor structure



	F3
	Bio
	hydrogenation
MUFA	
18:1 <i>c</i> 12	0.76
18:1 <i>t</i> 10	0.90
18:1 <i>t</i> 16	0.74
18:1 <i>t</i> 6+ <i>t</i> 8	0.80
18:1 <i>t</i> 9	0.85
PUFA	
18:2 <i>c</i> 9, <i>c</i> 12	0.62
Eigenvalue	0.10

	F4
	Long chain
	FA
22:0	0.68
MUFA	
18:1 <i>t</i> 4	0.74
PUFA	
20:3 <i>c</i> 8, <i>c</i> 11, <i>c</i> 14	0.75
20:4 <i>c</i> 5, <i>c</i> 8, <i>c</i> 11, <i>c</i> 14	0.72
20:5 <i>c</i> 5, <i>c</i> 8, <i>c</i> 11, <i>c</i> 14, <i>c</i> 17	0.76
22:5 <i>c</i> 7, <i>c</i> 10, <i>c</i> 13, <i>c</i> 16, <i>c</i> 19	0.70
Eigenvalue	0.08

Factor structure



	F5
	Desaturation
	FA
SFA	
18:0	-0.78
MUFA	
10:1c9	0.66
14:1c9	0.82
16:1c9	0.65
Eigenvalue	0.07

	F6
	Short chain
	FA
Individual FA	
SFA	
4:0	0.82
6:0	0.90
8:0	0.67
Eigenvalue	0.05

Factor structure



	F7 fat protein
Fat, %	0.66
Protein, %	0.87
Casein, %	0.88
Eigenvalue	0.05

	F8 Odd FA
Individual FA	
SFA	
11:0	0.66
13:0	0.75
15:0	0.69
Eigenvalue	0.05

	F9 CLA
Individual FA	
MUFA	
18:1 <i>t</i> 11	0.68
PUFA	
18:2 <i>c</i> 9, <i>t</i> 11	0.62
Eigenvalue	0.04

	F10 Linolenic Acid
MUFA	
18:3 <i>c</i> 9, <i>c</i> 12, <i>c</i> 15	0.76
Eigenvalue	0.04

	F11 Udder health
Lactose, %	-0.73
SCS, U	0.82
Eigenvalue	0.03

	F12 Vaccelenic acid
Individual	
FA	
18:2 <i>t</i> 11, <i>c</i> 15	0.91
Eigenvalue	0.02

Genetic parameters



Item	h^2_{AH}	h^2_H	Herd, %
F1: De novo FA	0.11 (0.05)	0.14 (0.07)	22 (4)
F2: MY - Branched FA	0.09 (0.04)	0.21 (0.07)	58 (4)
F3: Biohydrogenation	0.08 (0.03)	0.19 (0.08)	59 (4)
F4: Long chain FA	0.02 (0.01)	0.06 (0.03)	57 (4)
F5: Desaturation	0.27 (0.07)	0.31 (0.09)	13 (3)
F6: Short chain FA	0.08 (0.03)	0.16 (0.07)	51 (4)
F7: Milk fat protein	0.21 (0.06)	0.27 (0.08)	23 (4)
F8: Odd FA	0.09 (0.04)	0.13 (0.06)	31 (3)
F9: CLA	0.03 (0.01)	0.06 (0.03)	52 (4)
F10: Linolenic	0.10 (0.04)	0.20 (0.08)	53 (4)
F11: Udder health	0.13 (0.06)	0.14 (0.07)	8 (2)
F12: C18:2 <i>t</i> 11 <i>c</i> 15	0.04 (0.02)	0.05 (0.02)	25 (3)

Some considerations



- **Relevant reduction of the dimension of the system (<77%)**
- **New variables with biological meaning**
- **Grouping of original variables with similar origin and meaning**
- **Moderate values of heritability**

Communalinity



Milk yield, Kg	0.66	17:0	0.83		
Fat, %	0.62	17:0 <i>ante</i>	0.74		
Protein, %	0.90	17:0 <i>iso</i>	0.52	PUFA	
Casein, %	0.90	18:0	0.83	18:2 <i>c</i> 9, <i>c</i> 12	0.77
Lactose, %	0.63	20:0	0.60	18:2 <i>c</i> 9, <i>t</i> 11	0.84
SCS, U	0.69	22:0	0.63	18:2 <i>t</i> 11, <i>c</i> 15	0.87
Individual FA		MUFA		18:3 <i>c</i> 9, <i>c</i> 12, <i>c</i> 15	0.68
SFA		10:1 <i>c</i> 9	0.82	20:3 <i>c</i> 8, <i>c</i> 11, <i>c</i> 14	0.73
4:0	0.81	14:1 <i>c</i> 9	0.83	20:4 <i>c</i> 5, <i>c</i> 8, <i>c</i> 11, <i>c</i>	
6:0	0.93	16:1 <i>c</i> 9	0.83	14	0.70
8:0	0.93	16:1 <i>t</i> 9	0.60	20:5 <i>c</i> 5, <i>c</i> 8, <i>c</i> 11, <i>c</i>	
10:0	0.90	17:1 <i>c</i> 9	0.73	14, <i>c</i> 17	0.65
11:0	0.80	18:1 <i>c</i> 12	0.74	22:5 <i>c</i> 7, <i>c</i> 10, <i>c</i> 13,	
12:0	0.88	18:1 <i>c</i> 9	0.81	<u><i>c</i>16,<i>c</i>19</u>	<u>0.65</u>
13:0	0.76	18:1 <i>t</i> 10	0.83		
14:0	0.86	18:1 <i>t</i> 11	0.86		
14:0 <i>iso</i>	0.70	18:1 <i>t</i> 15 + <i>c</i> 11	0.31		
15:0	0.85	18:1 <i>t</i> 16	0.67		
15:0 <i>ante</i>	0.77	18:1 <i>t</i> 4	0.66		
15:0 <i>iso</i>	0.71	18:1 <i>t</i> 6+ <i>t</i> 8	0.77		
16:0	0.82	18:1 <i>t</i> 9	0.82		
16:0 <i>iso</i>	0.67				