Estimating daily yield and content of major fatty acids from single milking:

First approach

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Context

Reducing the frequency of milk recording will allow to reduce costs of milk recording. Numerous studies aim to estimate daily yields of milk, protein, and fat from single milking (e.g. Liu et al., 2000; Berry et al., 2006; Delorenzo and Wiggans 1986). Currently, many milk recording organizations propose an alternate milk recording scheme **but this involves a loss of accuracy in the predicted daily yields**. The milking interval (**MI**) effect included in the model proposed by the previous studies to estimate the daily yields of common production traits, are not often available and sometimes un-reliable.

Objective 1

➢ The development of **an useful, robust, and simple method for estimating accurate daily yields of milk, protein and fat from single milking without using the MI effect in the model.**

➢ Hypothesis: the MI can be reflected by the changes of milk yield and milk composition.

Objective 2

➢ Any model is currently available for milk fatty acids (**FA**)

→ The development of a similar method to predict the daily yields of the major milk FA such as **saturated** (**SFA**), **mono-unsaturated** (**MUFA**), **unsaturated** (**UFA**), **medium-chain** (MCFA) and **long-chain fatty acids** (**LCFA**).

Materials and Methods

Database

- Five dairy cows were followed daily throughout their lactation (March 2007 to December 2010). Each cow was milked twice a day. Milk yield was recorded for each cow at each milking.

- One milk sample (50 ml) was collected for each milking and cow and analyzed by MIR spectrometry (Delta Instrument, Lactoscope FTIR).
  → 1,440 spectra were recorded.

Prediction of FA content

- FA content (g/dl of milk) were estimated using specific MIR calibration equations developed by the Walloon Research Centre.

- Only equation having a RPD parameter (ratio of SD of the reference fatty acid values to the standard error of cross-validation) greater than 5 were used → SFA, MUFA, UFA, MCFA, and LCFA (Table 1).

Table 1. Statistical parameters for each calibration equation predicting the concentrations of fatty acid in milk (g/dL of milk).

	N	Mean	SD	R^2cv	RPD
SFA	143	2.68	0.72	0.99	13.4
MUFA	143	1.14	0.49	0.99	10.26
UFA	143	1.3	0.53	0.99	8.86
MCFA	142	1.99	0.56	0.96	5.17
LCFA	144	1.63	0.67	0.97	5.57

Replacing the "milking interval (MI)" effect by a combination of data easily recorded by the milk recording organization

- Study of correlation values between MI and dairy traits

Estimating daily content from single milking

- Eight regressions were tested to predict the milk FA content. Only the 8th model (**M8**) showing the best results is presented here. The fixed effects were the FA content estimated from AM or PM milking, AM or PM milk yield, AM or PM protein and fat contents, lactation number (first lactation and later lactation), days in milk (DIM, DIM^2, and DIM^3), season of calving (4 classes), season of test (4 classes).

- Comparison with the reference method proposed by Liu et al. (2000).

- Evaluation of model's accuracy and comparison of the studied models between themselves → study of the correlations between the calculated and estimated daily yield (r) and the root MSE (=RMSE) for M8 and for Liu's model (table 3).

Validation of developed models

- Internal validation by cross-validation (R^2cv and RPD)

Results and discussion

Table 2. **Descriptive statistics of the analyzed data (g/dl of milk) (N=1,440).**

		Mean	SD	Min.	Max.
MILK (l)	AM	15.27	5.57	1.30	29.00
	PM	10.84	3.98	1.20	24.00
	Daily	26.11	9.09	2.60	50.60
FAT	AM	32.32	8.73	10.79	63.13
	PM	43.53	7.78	13.01	70.12
	Daily	37.13	6.61	15.25	59.40
PROT	AM	32.02	2.91	22.35	41.15
	PM	32.98	3.27	22.15	43.46
	Daily	32.41	2.92	23.12	41.27
SFA	AM	25.85	7.44	7.11	50.83
	PM	34.16	6.62	9.66	53.28
	Daily	29.43	5.86	11.50	50.82
MUFA	AM	2.70	1.28	0.20	8.88
	PM	4.72	1.70	0.57	10.87
	Daily	3.55	1.24	0.76	9.65
UFA	AM	5.59	1.66	2.05	13.38
	PM	8.35	1.99	2.50	15.67
	Daily	6.76	1.46	2.69	12.95
MCFA	AM	21.17	6.35	6.12	43.37
	PM	27.80	5.67	9.15	44.06
	Daily	24.03	5.10	9.64	42.48
LCFA	AM	7.64	2.53	1.95	20.45
	PM	11.67	2.82	1.97	21.82
	Daily	9.35	2.12	3.55	18.58

Table 3. Correlation values between MI and studied dairy traits (N= 2,596).

Combination of effects	MI
Milk yield	0.41
Milk yield + Fat content + protein content	0.62
Milk yield + Fat content + protein content + dim + dim^2 + dim^3	0.71
Milk yield + Fat content + protein content + dim + dim^2 + dim^3 + lactation number	0.73
Milk yield + Fat content + protein content + dim + dim^2 +dim^3 + lactation number + season of test	0.74
Milk yield + Fat content + protein content + dim + dim^2 +dim^3 + lactation number + season of test + season of calving	0.74

Table 4. Correlation (R) and root mean squared errors (√MSE) between calculated and estimated contents based on morning or evening milking (N=1,440).

		AM milking		PM milking	
MODEL		**Liu's model (2000)**	**M8**	**Liu's model (2000)**	**M8**
Milk	R	0.97	NA	0.94	NA
	√MSE	2.19	NA	3.17	NA
FAT	R	0.89	NA	0.80	NA
	√MSE	3.07	NA	4.00	NA
PROT	R	0.97	NA	0.95	NA
	√MSE	0.71	NA	0.89	NA
SFA	R	0.91	**0.92**	0.83	**0.85**
	√MSE	2.54	2.34	3.29	3.08
MUFA	R	0.88	**0.91**	0.87	**0.88**
	√MSE	0.60	0.52	0.63	0.58
UFA	R	0.86	**0.88**	0.82	**0.84**
	√MSE	0.77	0.68	0.85	0.79
MCFA	R	0.90	**0.93**	0.85	**0.87**
	√MSE	2.06	1.91	2.69	2.54
LCFA	r	**0.92**	**0.88**	0.80	**0.82**
	√MSE	2.07	1.00	1.29	1.21

MI effect could be partially replaced by a combination of dairy traits easily recorder by the milk recording organizations such as milk yield, fat and protein contents, classes of lactation stage, month of test, and month of calving (Table 3)

- **Similar results** obtained from M8 (non inclusion of MI) and the model proposed by Liu *et al.* (2000; inclusion of MI).

- **High correlation values** between calculated and estimated contents. Globally, **highest correlations for M8**.

- **Daily estimations based on evening milking** (r from 0.82 to 0.88) **are less accurate** than those based on morning milking (r de 0.88 à 0.93).

- **RPD values were lower than expected** (from 1.26 to 2.43 for AM (Table 5); from 0.86 to 2.05 for PM). This could be explained by the size of the dataset used → new validation on a larger dataset.

Table 5. Mean, SD, SECV, R^2cv, and RPD values obtained from daily predictions obtained from data of AM milking and M8.

	N	Mean	SD	R^2cv	RPD
SFA	1440	753.1	264.95	0.88	1.51
MUFA	1440	92.23	49.18	0.88	1.56
UFA	1440	174.98	72.75	0.88	2.00
MCFA	1440	612.03	211.2	0.87	1.26
LCFA	1440	242.42	104.33	0.88	2.43

Conclusions

- According to the used dataset, **MI effect could be replaced by a combination of dairy traits easily recorded by milk recording organizations.**
- From the obtained results, **the daily yields of FA** can be predicted with **an accuracy similar to the fat content. M8 model provided better results** than the model proposed by Liu et al. (2000) except for LCFA. Daily **FA predictions from AM milking** were **more accurate.**

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