



# Grass for biorefinery- Dairy cow responses to diets based on solid fraction of grass silage



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Natural Resources Institute Finland (Luke), Jokioinen, Finland

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# Alternative, fibrous feed resources for ruminants

- Grazing ruminants have a great access to energy in the form of fibrous feeds because of their specialized digestion
- This system with pregastric retention and fermentation with symbiotic microorganisms has allowed ruminants to utilize fibrous feed resources
- Separation of fibrous silage solid fraction for ruminants feed could enhance the utilization of silage in farms

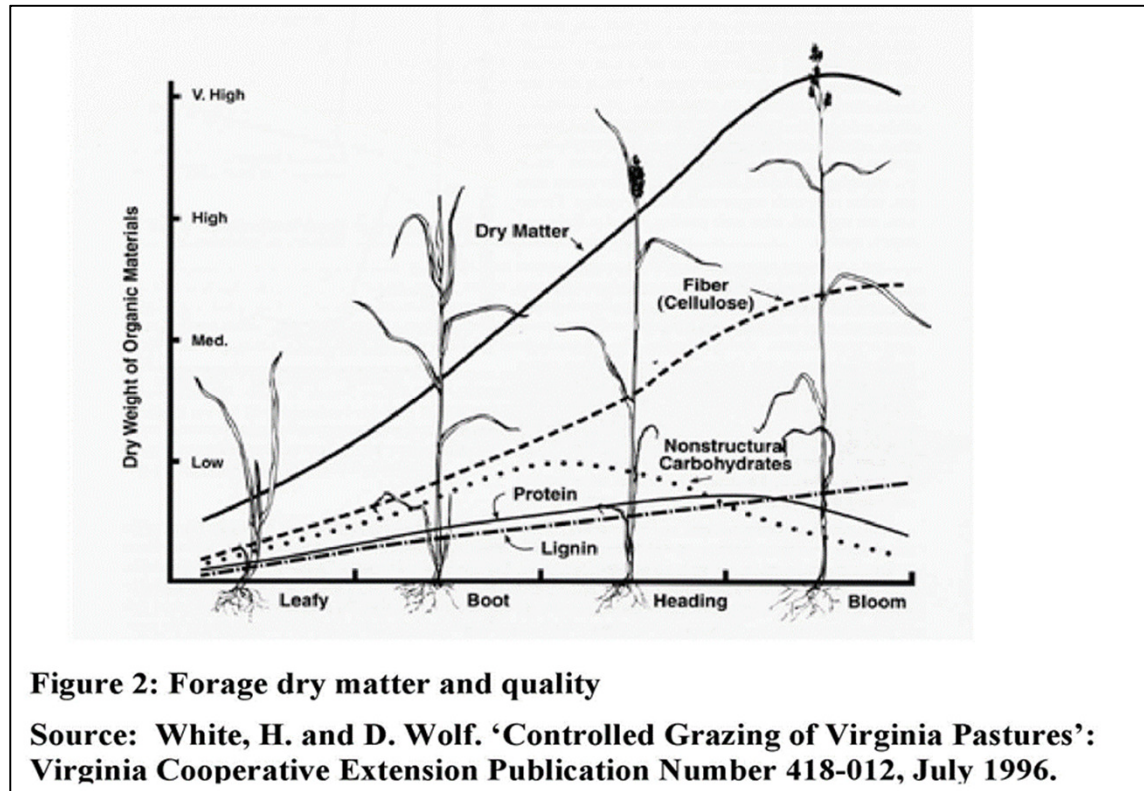
# Separated solid fraction in ruminant diets

- There is limited information of the nutritive value of separated solid fraction of grass silage
- Increased fibre content, reduced crude protein (CP) content and decreased digestibility have been reported
- Similar changes have been detected due to delayed harvest of **grass silage**
- **in both cases fibre intake increases**



# Changes in grass maturity vs. silage solid fraction in diet => fibre intake increases

- With increasing maturity of grass also the fibre **digestibility** decreases ...



- ...but in the present study fibre digestibility stayed the same, only the **amount** of fibre increased when silage solid fraction was included in the diet

# The aim of this study

- To evaluate the effect of silage solid fraction fed to dairy cows on:

- feed intake
- ruminal fermentation
- digestibility
- milk yield and milk composition

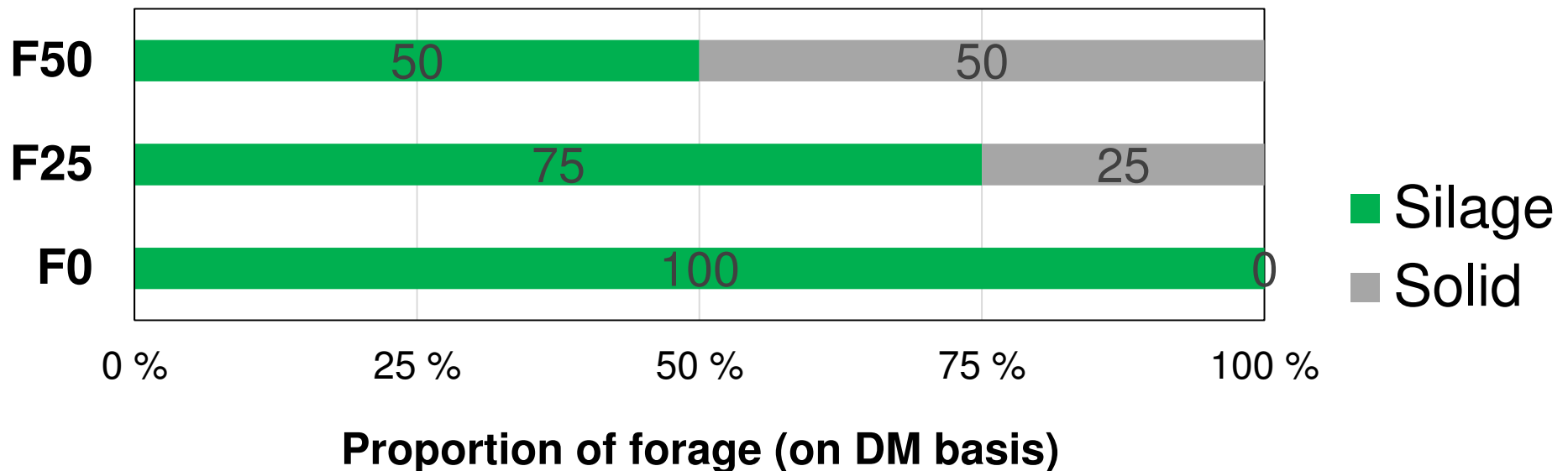
## HYPOTHESIS:

There is no reduction in milk production in the diet containing silage solid fraction compared to original silage



## Materials and Methods

- 24 multiparous Nordic Red cows, 4 rumen fistulated
- Experimental treatments: **F0**, **F25** and **F50**:



- Imbalanced change over design, 3 diets, 2 periods of 21 days

# Feeds

## Concentrate

- 13 kg /d standard concentrate

## Forage (*ad libitum*)

- 1st cut grass silage, mixed timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*)
- Harvested 21<sup>st</sup> and 22<sup>nd</sup> June 2017, preserved with formic acid-based additive (AIV 2 plus, 5 l/ton).
- Silage was fractionated into liquid and solid fractions

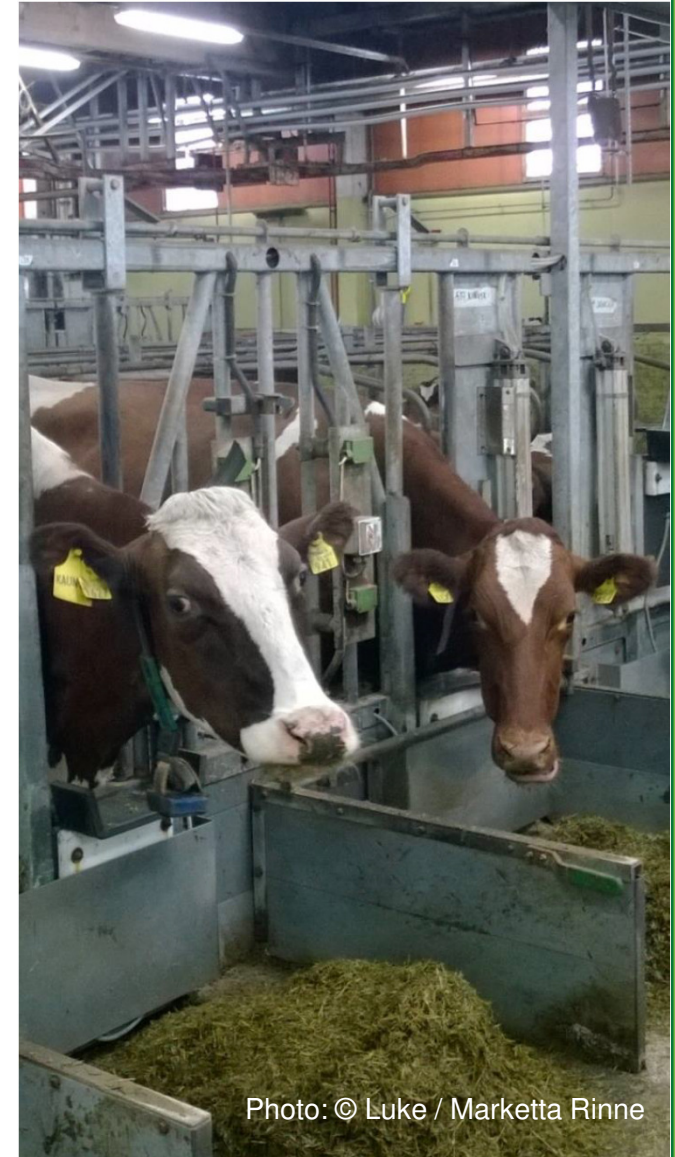
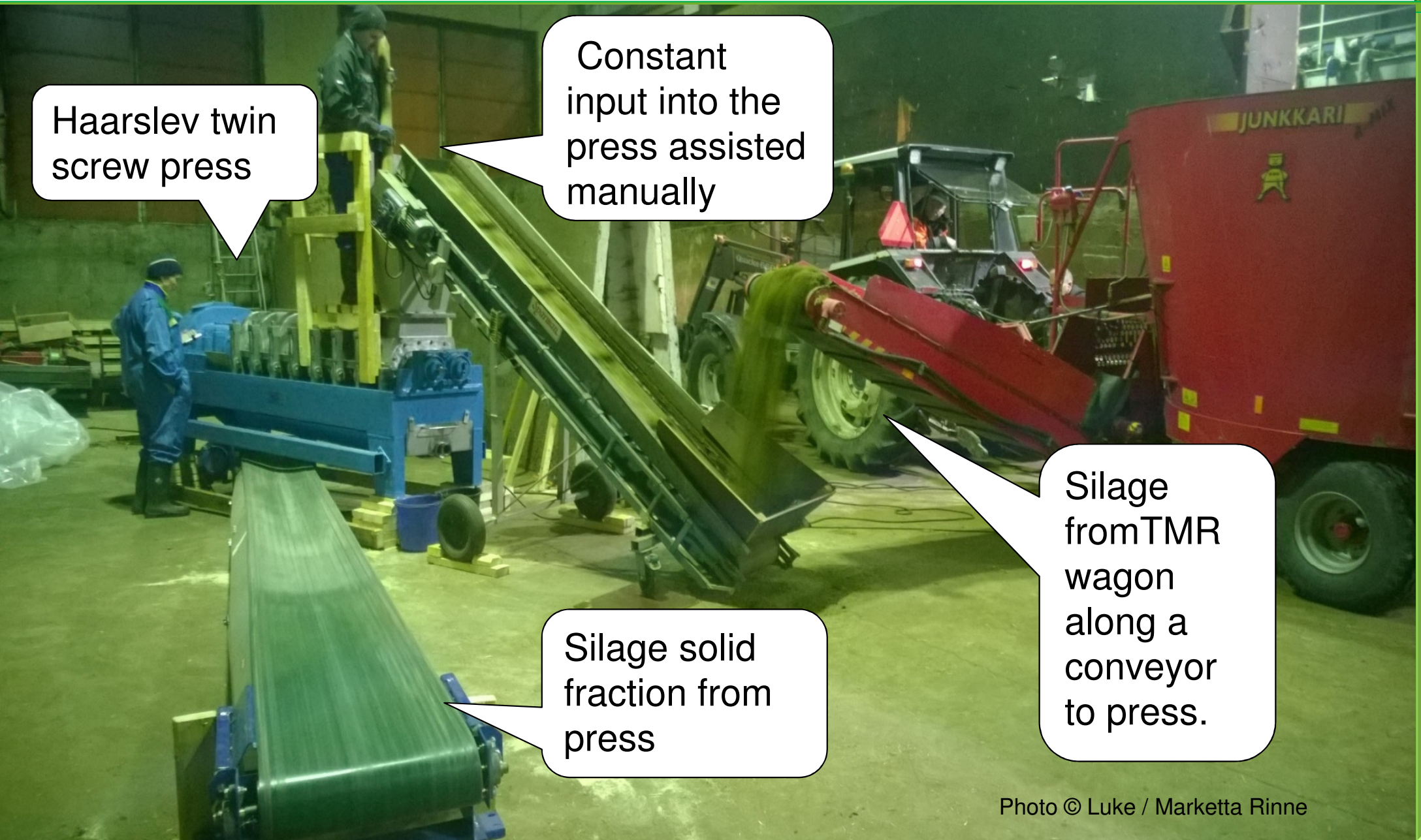


Photo: © Luke / Marketta Rinne

# Fractionation of silage in Jokioinen January 2018



# Constant input into the press was ensured by compressing silage to the screws manually



Photo: © Luke / Marketta Rinne



Photo: © Luke / Marketta Rinne



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# Haarslev twin screw press

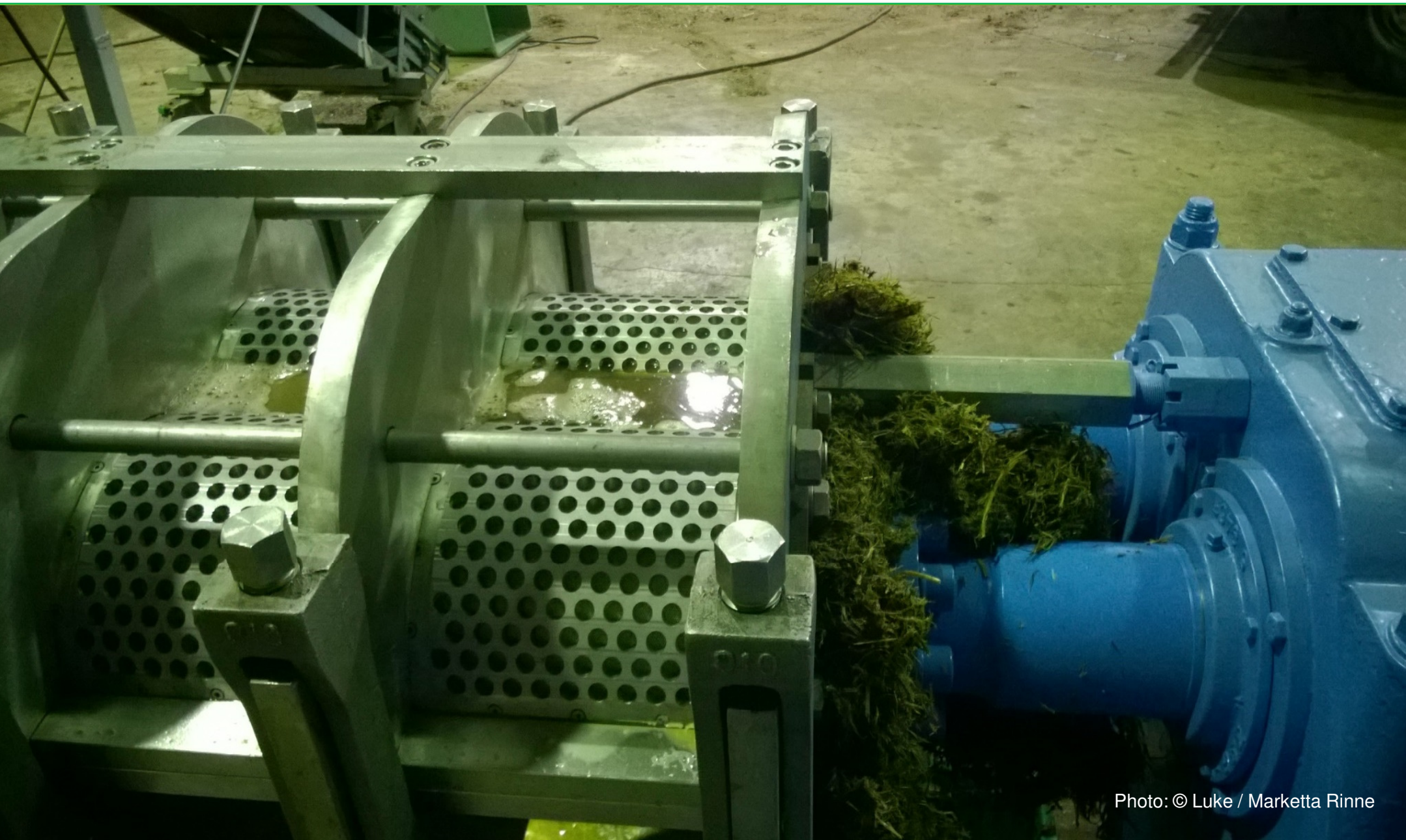
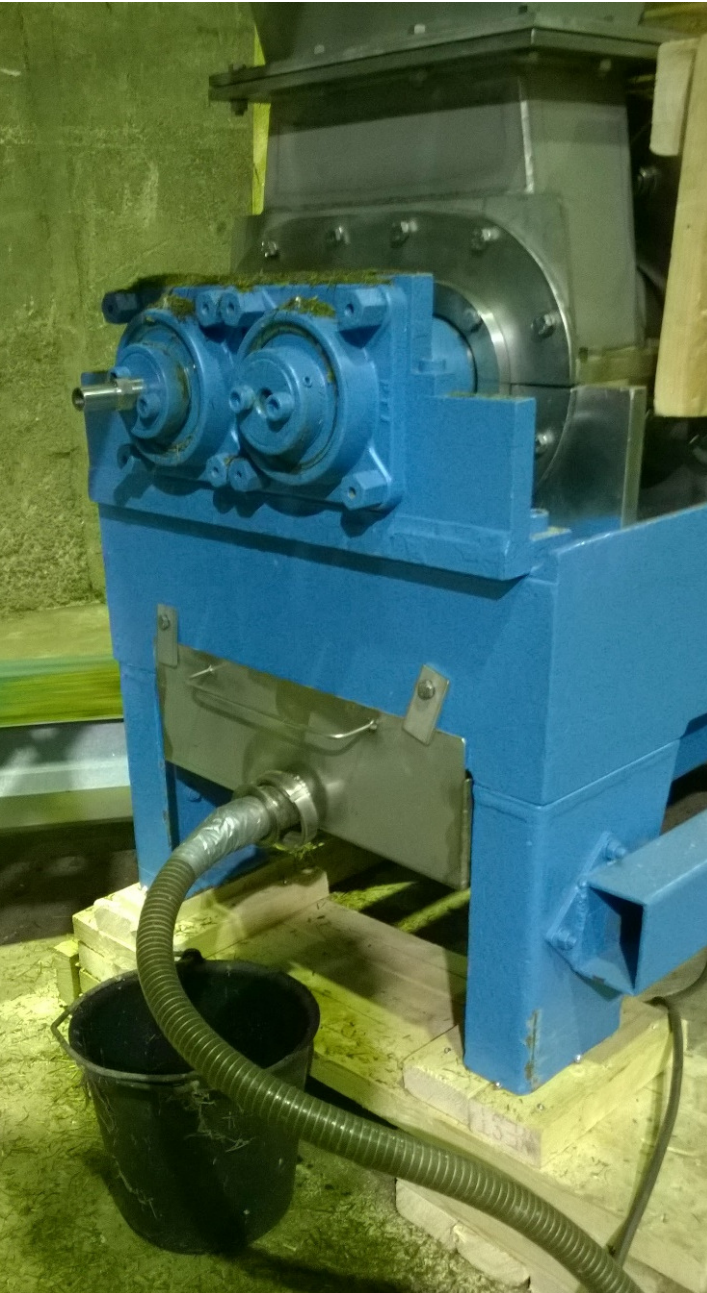


Photo: © Luke / Marketta Rinne

# Separation of the liquid fraction

- Liquid was gathered from the bottom of Haarslev twin screw press and pumped into containers
- The liquid was used in an a feeding trial for fattening pigs
  - Results not presented here



# Silage solid fraction from twin screw press



## Silage (left) and silage solid fraction (right)



Photo: ©Luke / Marcia Franco

# In poster session:

- Description of production of the silage solid fraction used in this experiment:
- Stefański, T., Franco, M., Savonen, O., Jalava, T., Winquist, E., Rinne, M. 2018. Grass silage for biorefinery – Separation efficiency and aerobic stability of silage, solid and liquid fractions. Nordic Feed Science Conference, Uppsala, Sweden, 12-13 June 2018.

## Grass silage for biorefinery – Separation efficiency and aerobic stability of silage and solid fraction

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### Introduction

- A green biorefinery concept involves processing of green biomass into a range of products
- Grasses provide versatile properties as raw material for green biorefinery
- Ensiling allows green biomass to be processed all year round
- Green biorefinery usually starts with mechanical separation of liquid and solid fractions
  - Solid fractions: feed for ruminants, biogas insulation boards or hydrolysed into simple sugars for further processes
  - Liquid fractions: feeds for pigs and cows and raw material for extraction of lactic acid, volatile fatty acids and amino acids

The aim of the current study was to compare three liquid-solid separation methods on liquid yield, composition and retained compounds in liquid and evaluate the effect of preservatives on aerobic stability of silage and solid fraction using two indicators

### Materials and Methods

#### Three processing methods

- Farm scale twin screw press (FTS; Haanstrup Industries A/S, Sønderborg, Denmark)
- Laboratory scale twin screw press (LTS; Angel Jaiber Ltd, Busan, South Korea)
- Laboratory scale pneumatic press (LPP; Luke in-house built equipment, Jokioinen, Finland)



#### Aerobic stability: 3 × 2 × 3 factorial design

- Three types of raw material: silage, solid fraction or solid fraction with added water (to the same DM as the silage)
- Two forms of raw material: as such or as part of TMR
- Three preservative treatments: Control without preservative (C), Formic and propionic acid based preservative at 3 Mon (FAPA), Propionic acid based preservative at 3 Mon (PA)

#### Aerobic stability measurement



### Conclusions

- Twin screw presses, farm and laboratory scale, resulted in higher liquid yield and greater amount of retained compounds in liquid fraction as compared to a pneumatic press.
- Preservatives extended aerobic stability of silage, solid fraction and solid fraction added with water used as such or in a TMR.

Table 1 Chemical composition of original silages, and solid and liquid fractions

	FTS			LTS			LPP		
	Silage	Solid	Liquid	Silage	Solid	Liquid	Solid	Liquid	
Dry matter, g/kg	264	430	63	234	407	88	210	70	
Crude protein, g/kg	71	43	197	70	43	193	88	208	
Crude protein, %	14.2	10.7	27.8	14.4	10.6	26.2	11.8	27.1	
Crude protein, g/kg	80.8	70.7	-	80.8	70.7	-	80.8	70.7	
Crude protein, %	30	16	3	30	16	3	30	16	
Digestible organic matter in the solid, g/kg	70.4	88.0	-	70.4	88.0	-	70.4	88.0	

FTS: Farm scale twin screw press, LTS: laboratory scale twin screw press, LPP: laboratory scale pneumatic press. Values are means.

Table 2 Effect of processing methods on liquid yield, composition and retained compounds in liquid

	FTS	LTS	LPP	SEM
Liquid yield, g/kg	6.37 <sup>a</sup>	6.87 <sup>b</sup>	6.34 <sup>a</sup>	0.09
Liquid dry matter (DM), g/kg	7.7 <sup>a</sup>	8.4 <sup>b</sup>	8.0 <sup>a</sup>	0.4
Crude protein, g/kg	2.70 <sup>a</sup>	2.63 <sup>a</sup>	2.71 <sup>a</sup>	0.03
Crude protein, %	18.8 <sup>a</sup>	17.8 <sup>a</sup>	18.8 <sup>a</sup>	0.3
Crude protein, g/kg	6.37 <sup>a</sup>	6.87 <sup>b</sup>	6.34 <sup>a</sup>	0.09
Crude protein, %	6.37 <sup>a</sup>	6.87 <sup>b</sup>	6.34 <sup>a</sup>	0.09
Crude protein, g/kg	6.37 <sup>a</sup>	6.87 <sup>b</sup>	6.34 <sup>a</sup>	0.09
Crude protein, %	6.37 <sup>a</sup>	6.87 <sup>b</sup>	6.34 <sup>a</sup>	0.09

FTS: Farm scale twin screw press, LTS: laboratory scale twin screw press, LPP: laboratory scale pneumatic press, SEM: standard error of the mean. Values within the same row without same superscript differ (P<0.05).

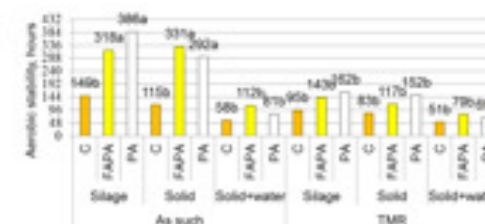


Figure 1 Effect of preservation on aerobic stability measured through increasing in temperature. Preservation (P<0.001), Silage vs Solid used as such (P<0.001), Silage vs Solid in TMR (P<0.001), Silage vs Solid in TMR (P<0.001), Solid as such vs Solid in TMR (P<0.001), Silage vs Solid-water as such (P<0.001), Silage vs Solid-water in TMR (P<0.001), Solid as such vs Solid-water as such (P<0.001), Solid as such vs Solid-water in TMR (P<0.001), Solid-water as such vs Solid-water in TMR (P<0.001).

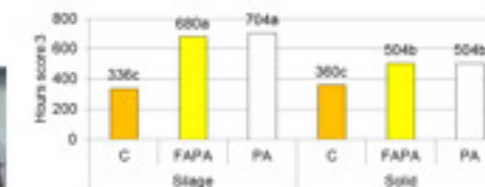


Figure 2 Effect of preservation on aerobic stability measured through visual inspection. Silage vs Solid (P<0.001), Preservation in silage (P<0.001), Preservation in solid (P<0.001), Preservation in TMR (P<0.001), Preservation in TMR (P<0.001), FAPA vs PA (P<0.001), FAPA vs PA (P<0.001), FAPA vs PA (P<0.001), FAPA vs PA (P<0.001).

## Feeding of the cows

- **F0** (silage) was given from automatic feeding wagon
- **F25** and **F50** => silage solid fraction and silage were mixed in a TMR wagon and delivered by hands at the same time as automatic wagon fed F0 (07:00, 13:00, 16:00 and 18:00)
- Concentrate was given from automatic feeders and in milking parlour



## Milk sampling

### Milk samples

- were taken on last two days of both periods
- were analyzed for **fat, protein, lactose** and **urea**
- milk constituents were calculated as a weighted mean according to milk yield.

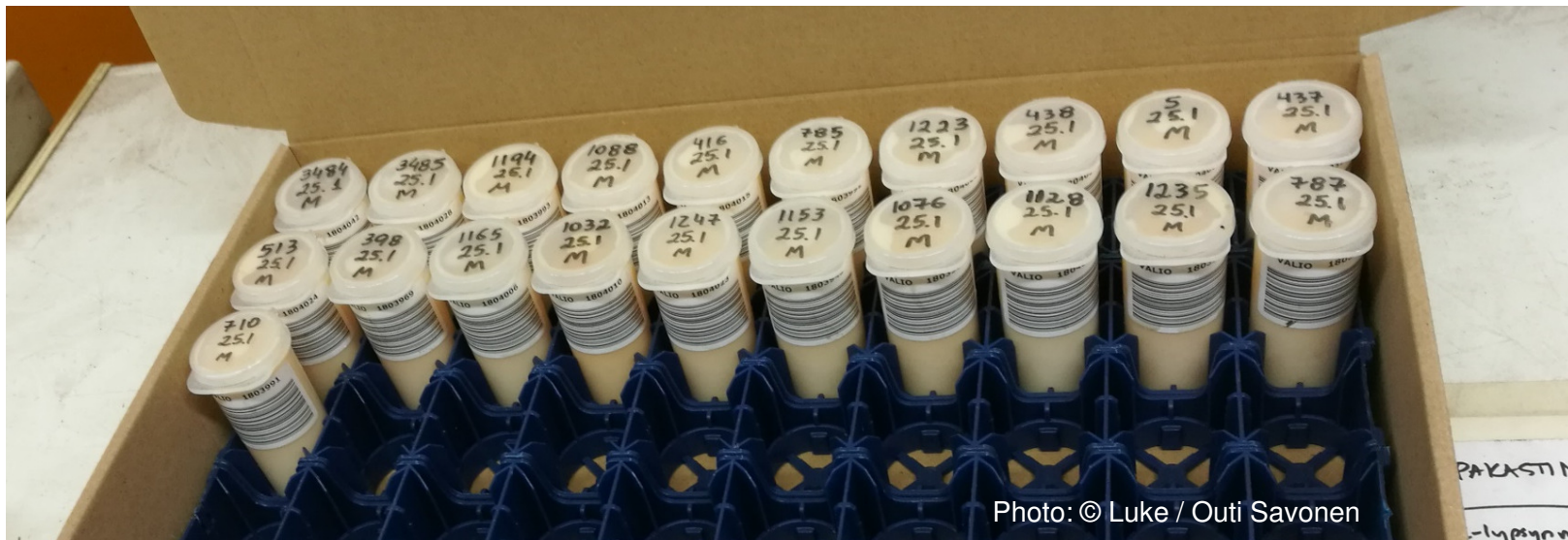


Photo: © Luke / Outi Savonen

# Rumen fluid sampling

- Rumen fluid samples were taken during the third day in the last week of both periods
- For treatments F0 and F50 only
- Samples were taken 0, 3 and 6 hours after feeding and analyzed for

**pH,  $\text{NH}_3$  and volatile fatty acids (VFA)**



Photo: © Luke / Marketta Rinne

## Faecal sampling for diet digestibility determination

- Faecal samples were taken on four days during the last week of both periods
- Crab samples were taken twice a day
- Samples were analyzed for

dry matter (**DM**), **ash**, crude protein (**CP**), neutral detergent fibre (**NDF**) and acid insoluble ash (**AIA**).

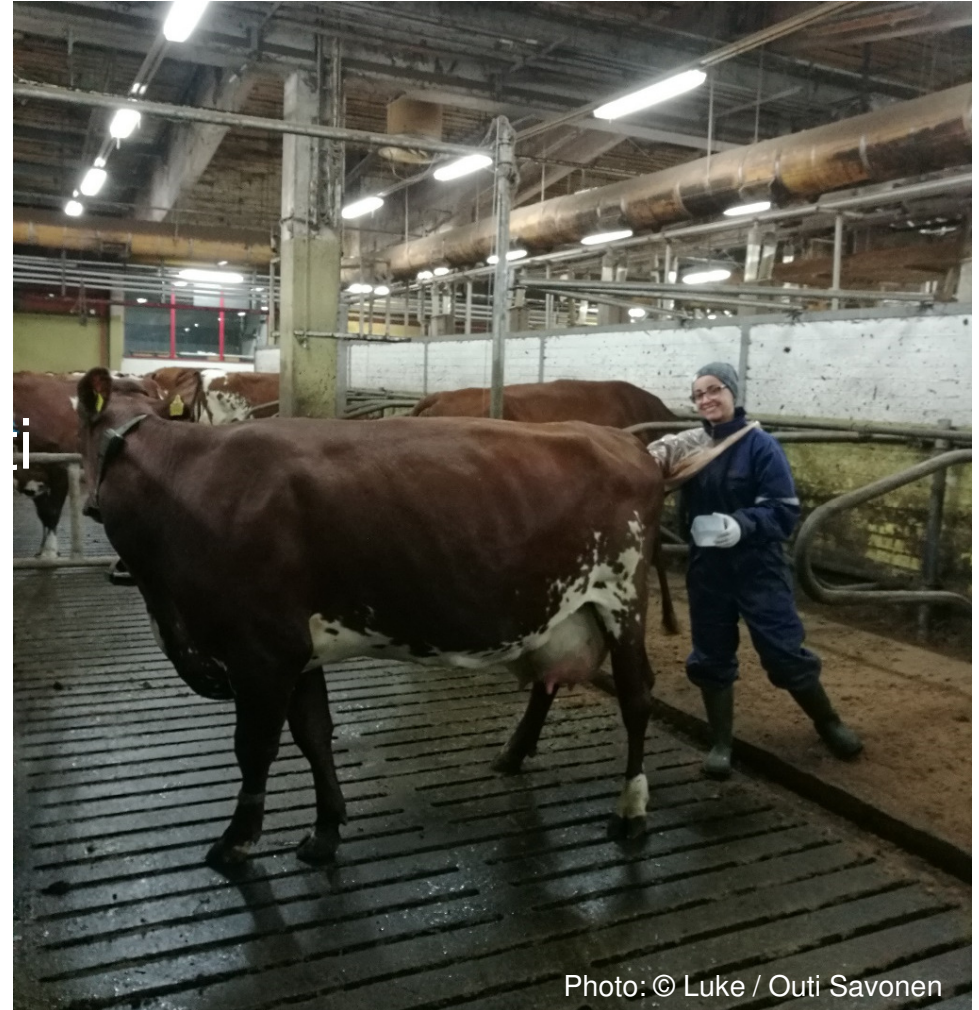


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# Data analysis

- Data was analyzed using a MIXED procedure of SAS as 5% probability
- Dietary treatment as the **fixed effect** and cow as the random **effect**
- **Linear** (Lin) and **quadratic** (Quad) effects of addition of silage solid fraction were evaluated using orthogonal and polynomial contrasts



## Fermentation quality of the original silage was good but it was rather wet

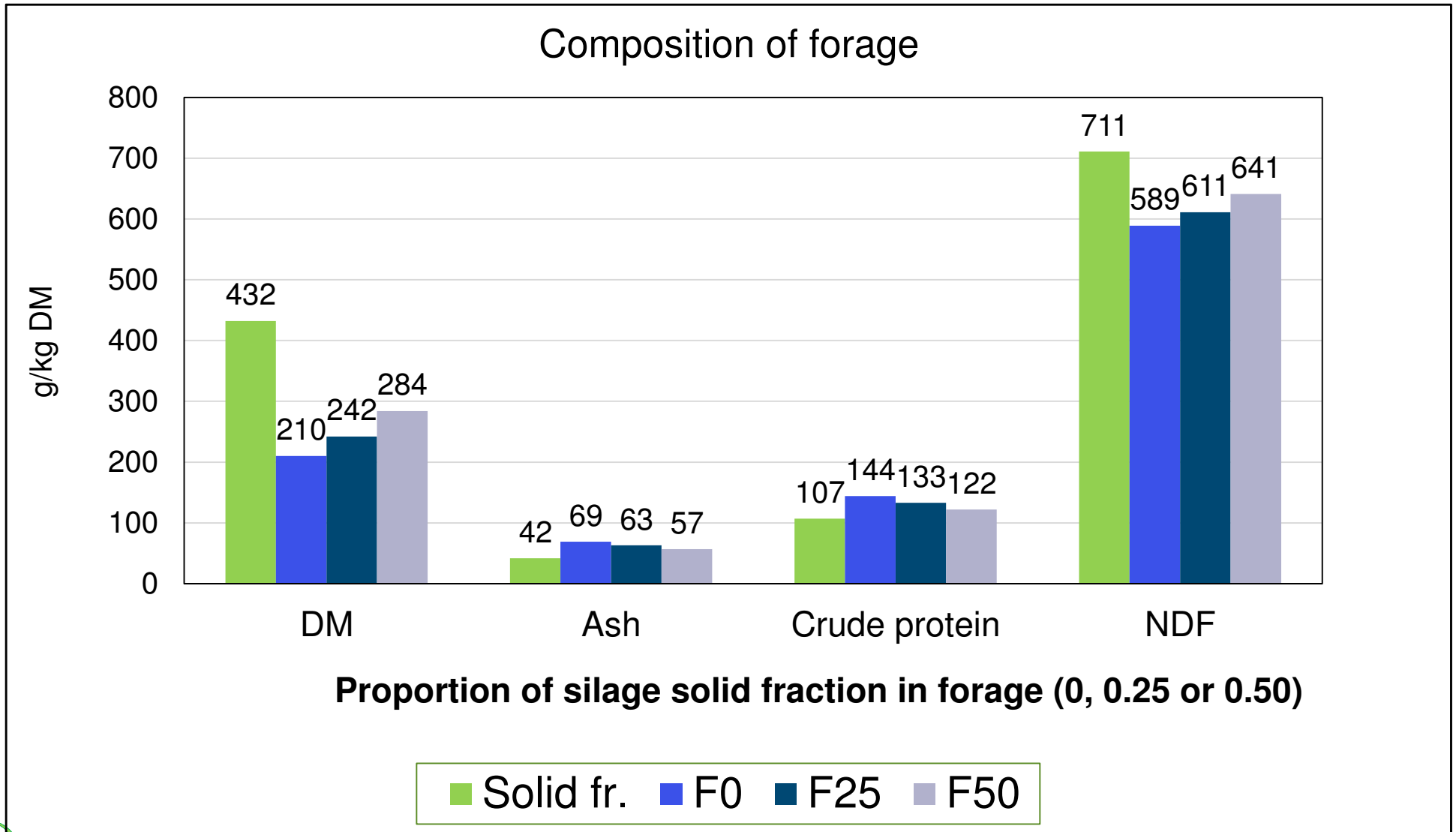
Variable	Result
Dry matter (DM, g/kg)	210
pH	4.0
Ammonia N, g/kg N	30
Lactic acid, g/kg DM	50
Acetic acid, g/kg DM	18
Propionic acid, g/kg DM	0.6
Butyric acid, g/kg DM	0.9

# Effect of pressing on liquid yield, composition and retained compounds in liquid (Haarslev twin screw press)

Variable	Result
Liquid yield, g liquid/kg original silage	0.576
DM in liquid, g/kg	71
In liquid, g/kg DM	
Crude protein (CP)	270
Ash	189
Amount retained in liquid as proportion of original silage	
DM	0.193
CP	0.361
Ash	0.535

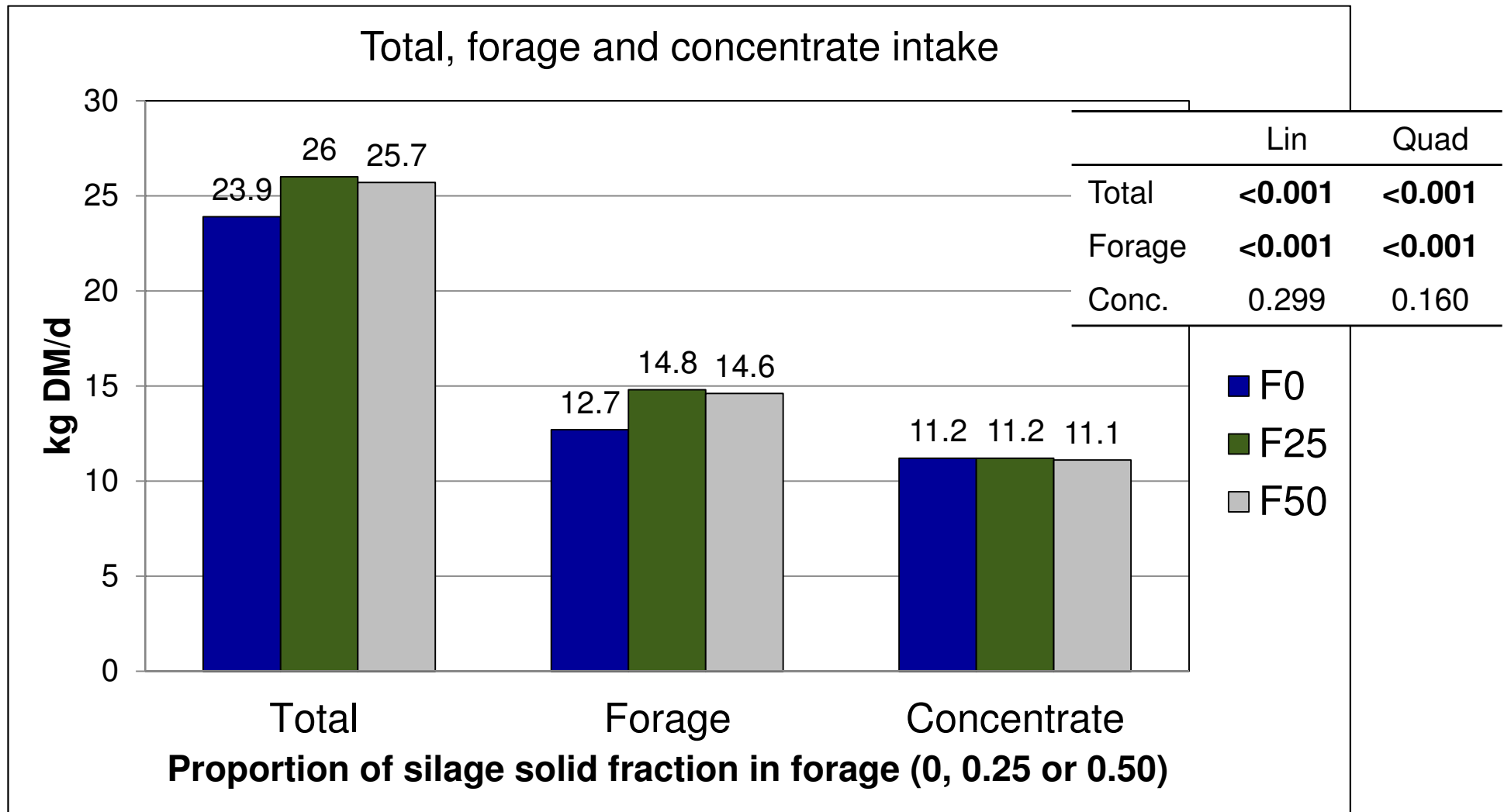
Stefański, T, Franco, M, Savonen, O, Jalava, T, Winqvist, E & Rinne, M. 2018. Grass silage for biorefinery – separation efficiency and aerobic stability of silage and solid fraction. Proc of the 9<sup>th</sup> Nordic Feed Science Conference, Uppsala, Sweden, June. 2018.

**The composition of forage changed systematically when the amount of silage solid fraction was increased.**

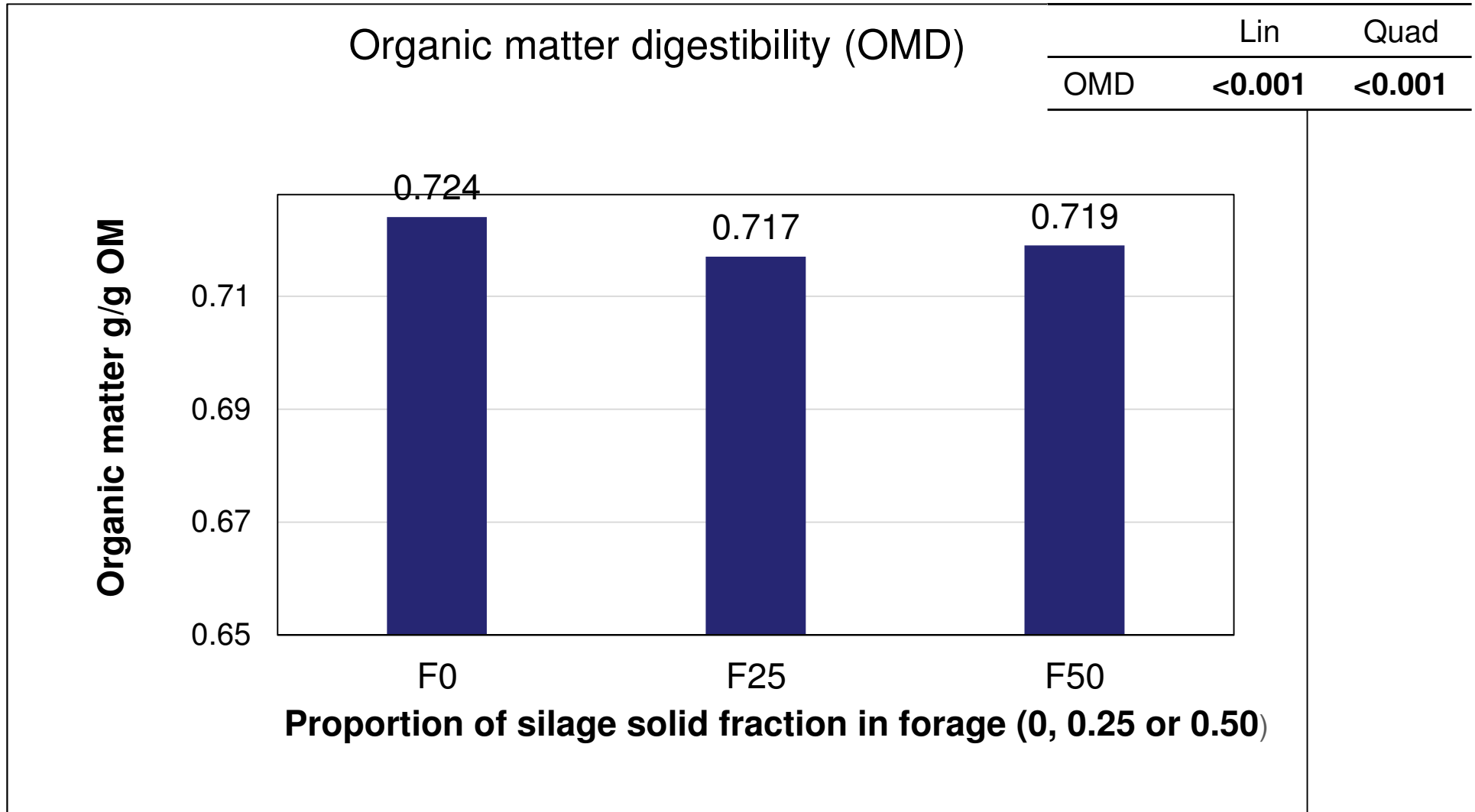


**Cows fed F25 managed to increase forage intake but cows fed F50 were unable to further compensate.**

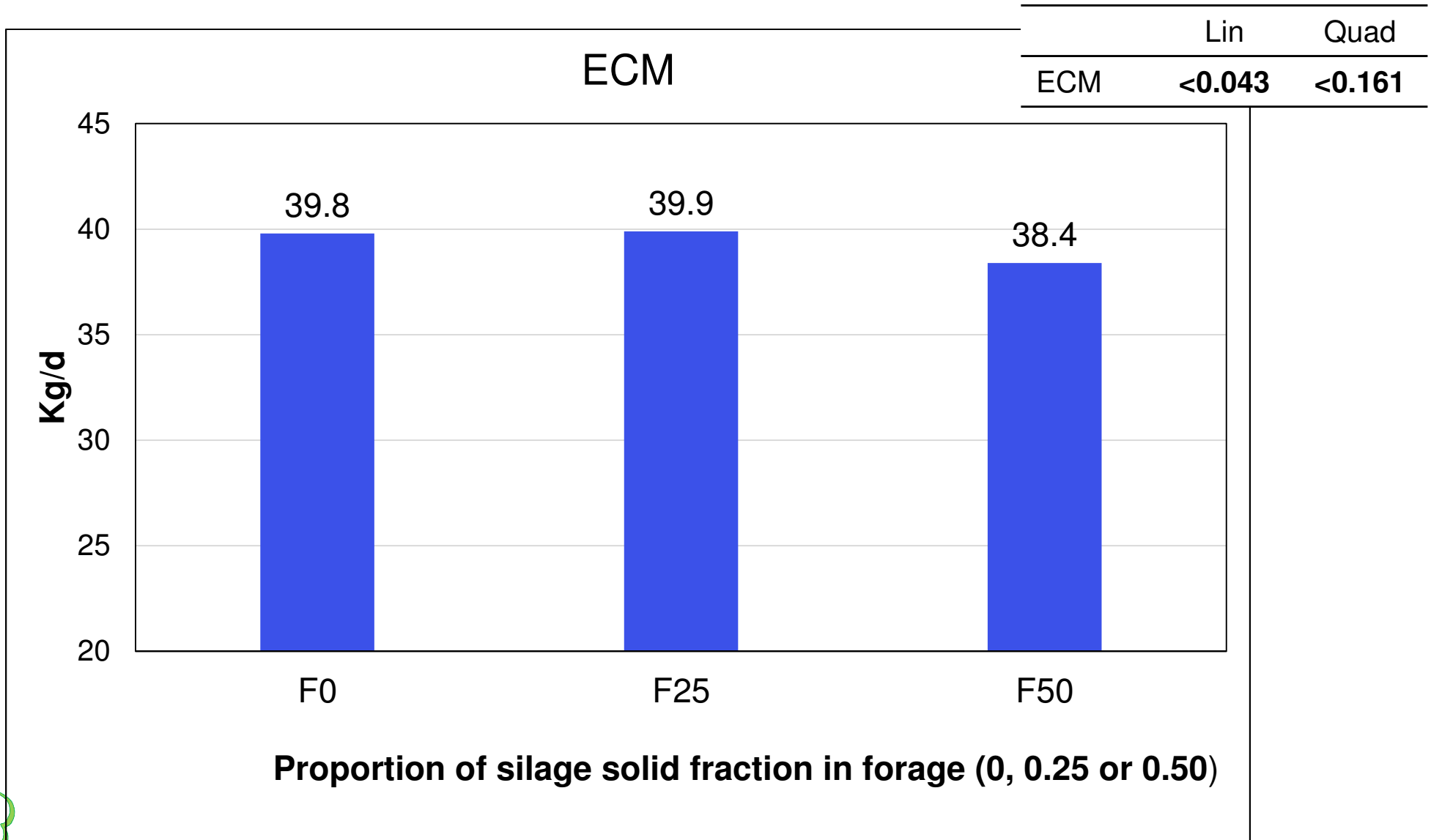
**There were no differences in concentrate intake.**



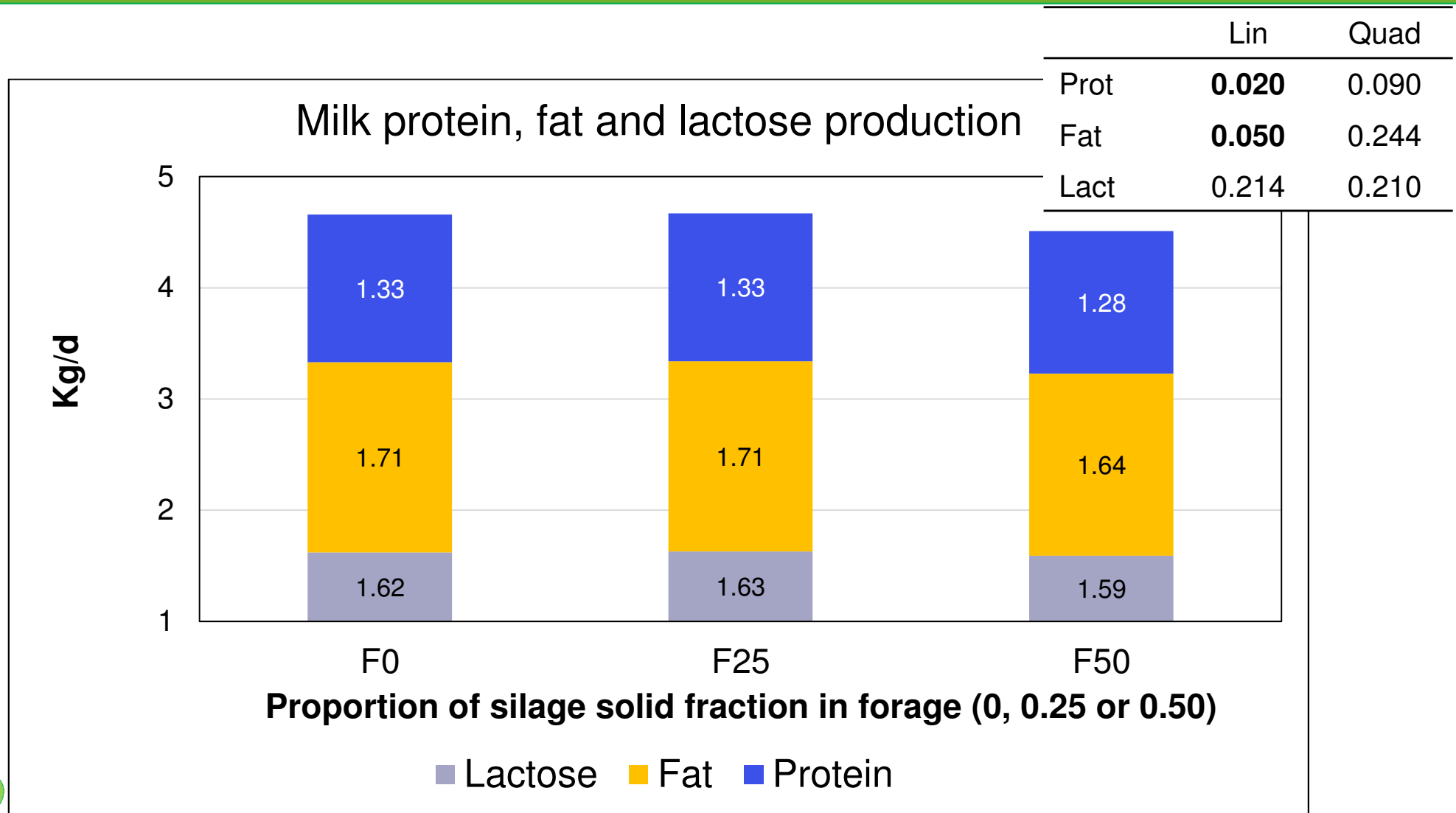
# Diet organic matter digestibility (OMD) decreased slightly with increasing silage solid fraction proportion.



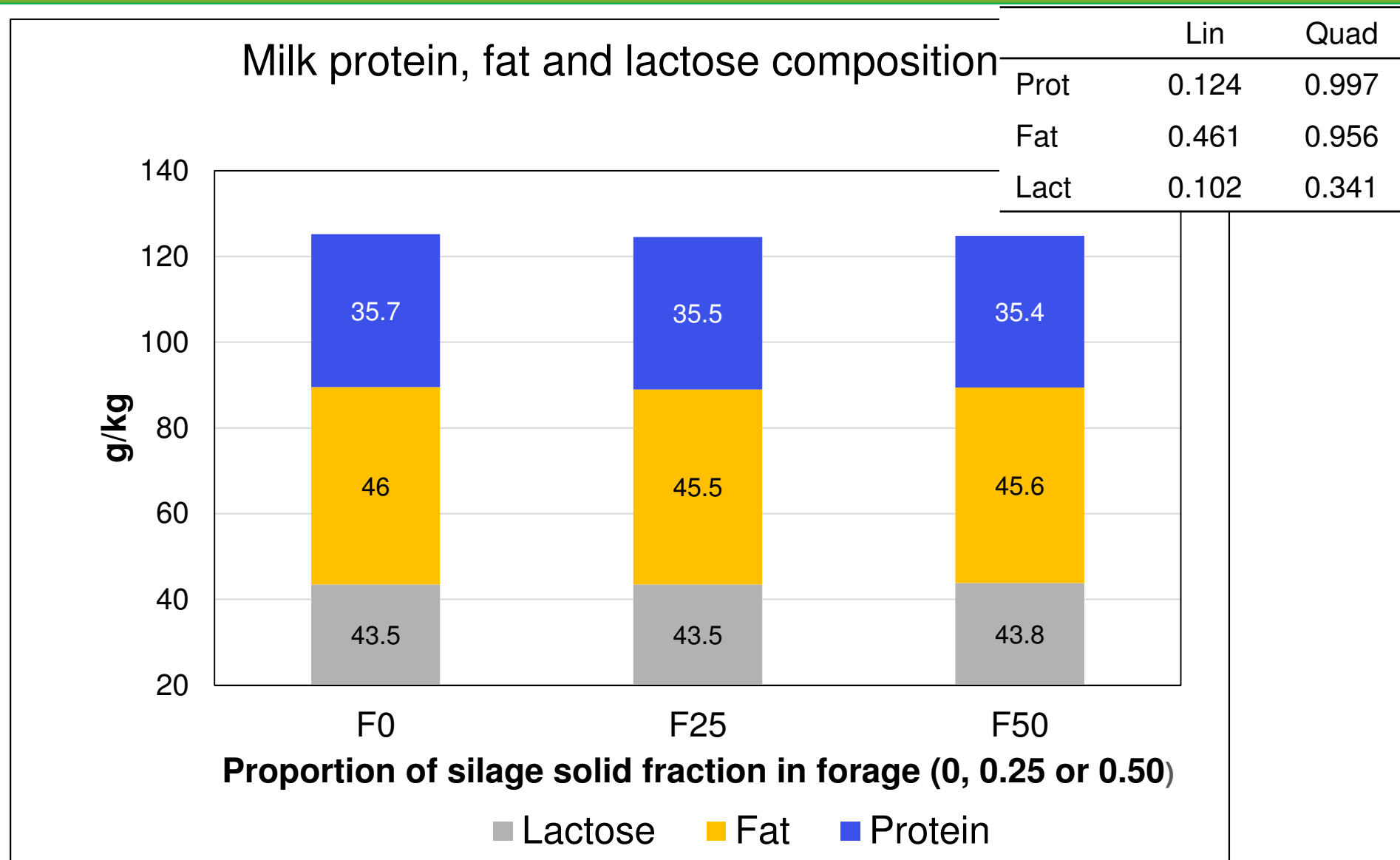
**ECM production decreased linearly when silage solid fraction increased in diet.**



# Milk fat and milk protein production decreased linearly when the proportion of silage solid fraction increased in diet.

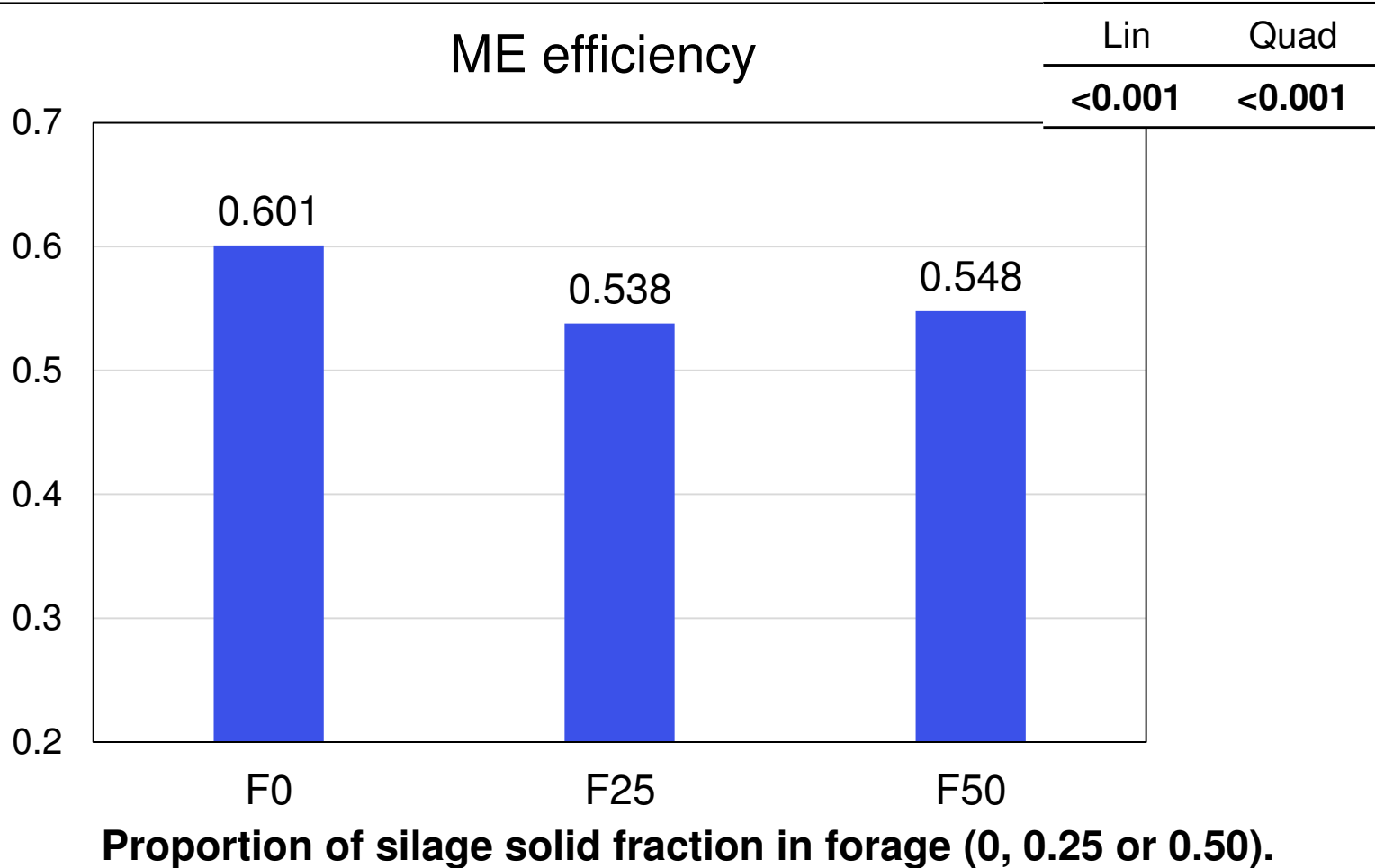


**There were no differences in milk composition between the diets.**



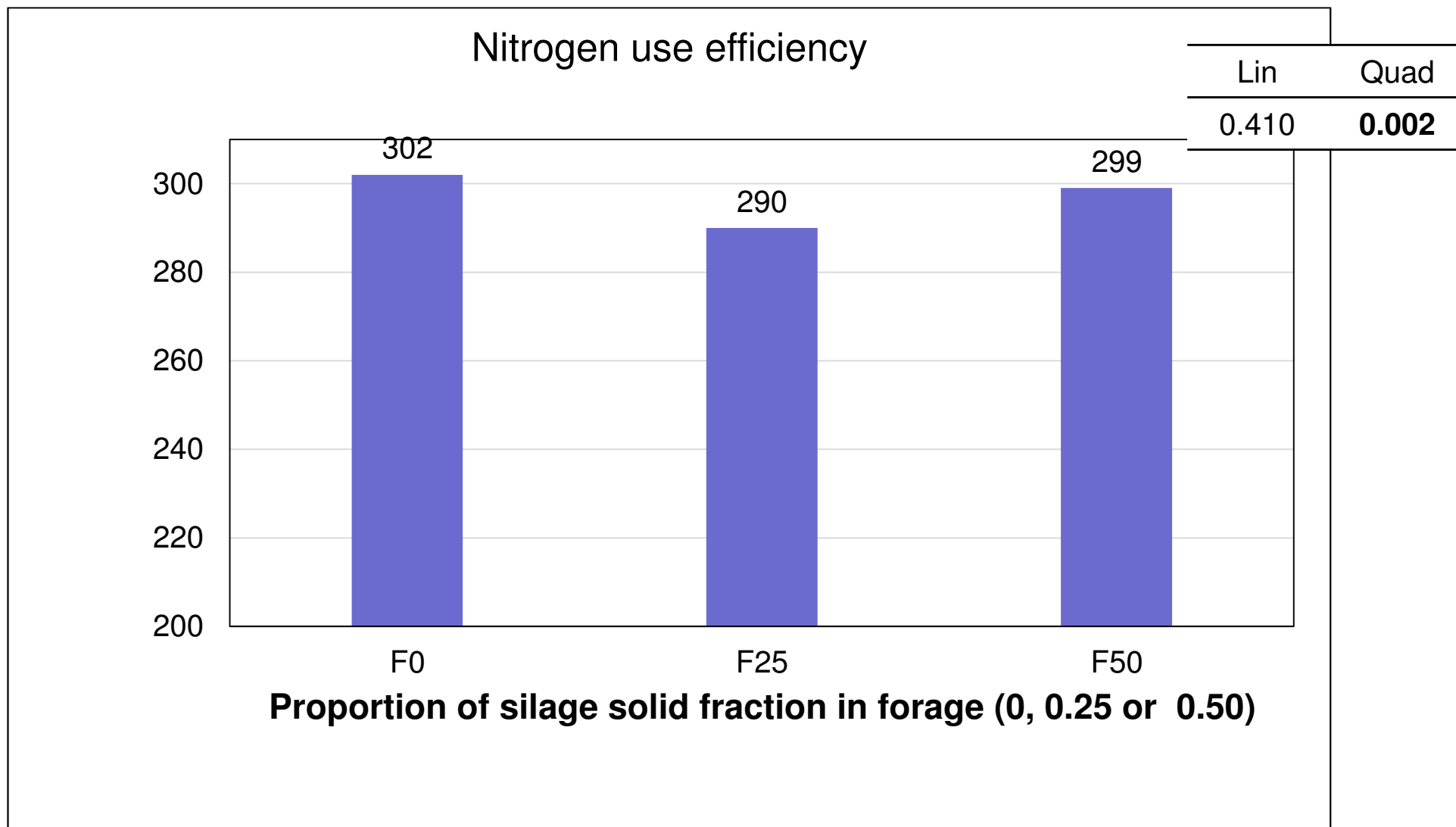
**In terms of milk production efficiency using the original silage resulted in highest values.**

(Metabolizable energy (ME) excreted in milk) / (ME intake - ME for maintenance)

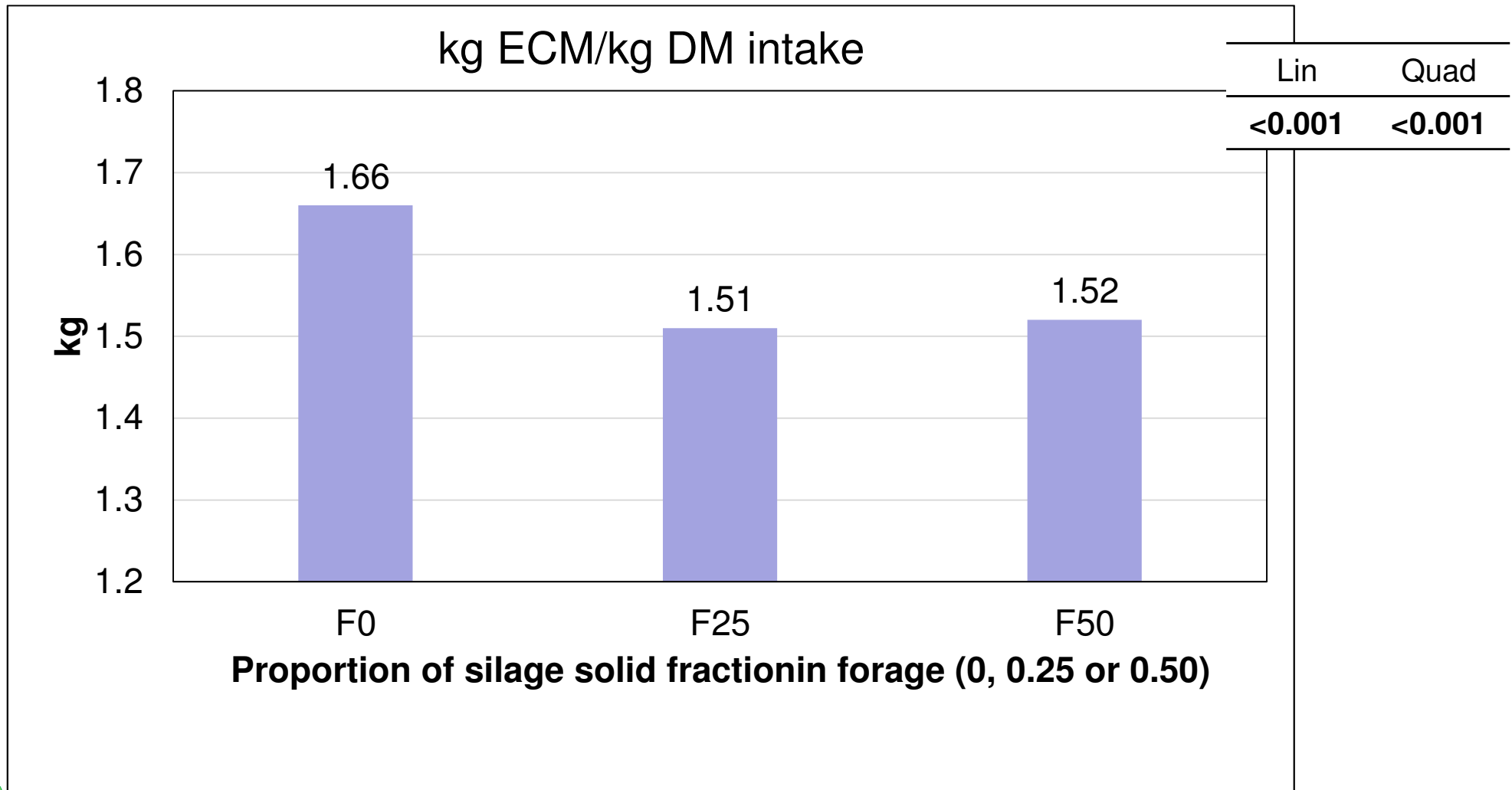


# Nitrogen use efficiency was the highest in original silage.

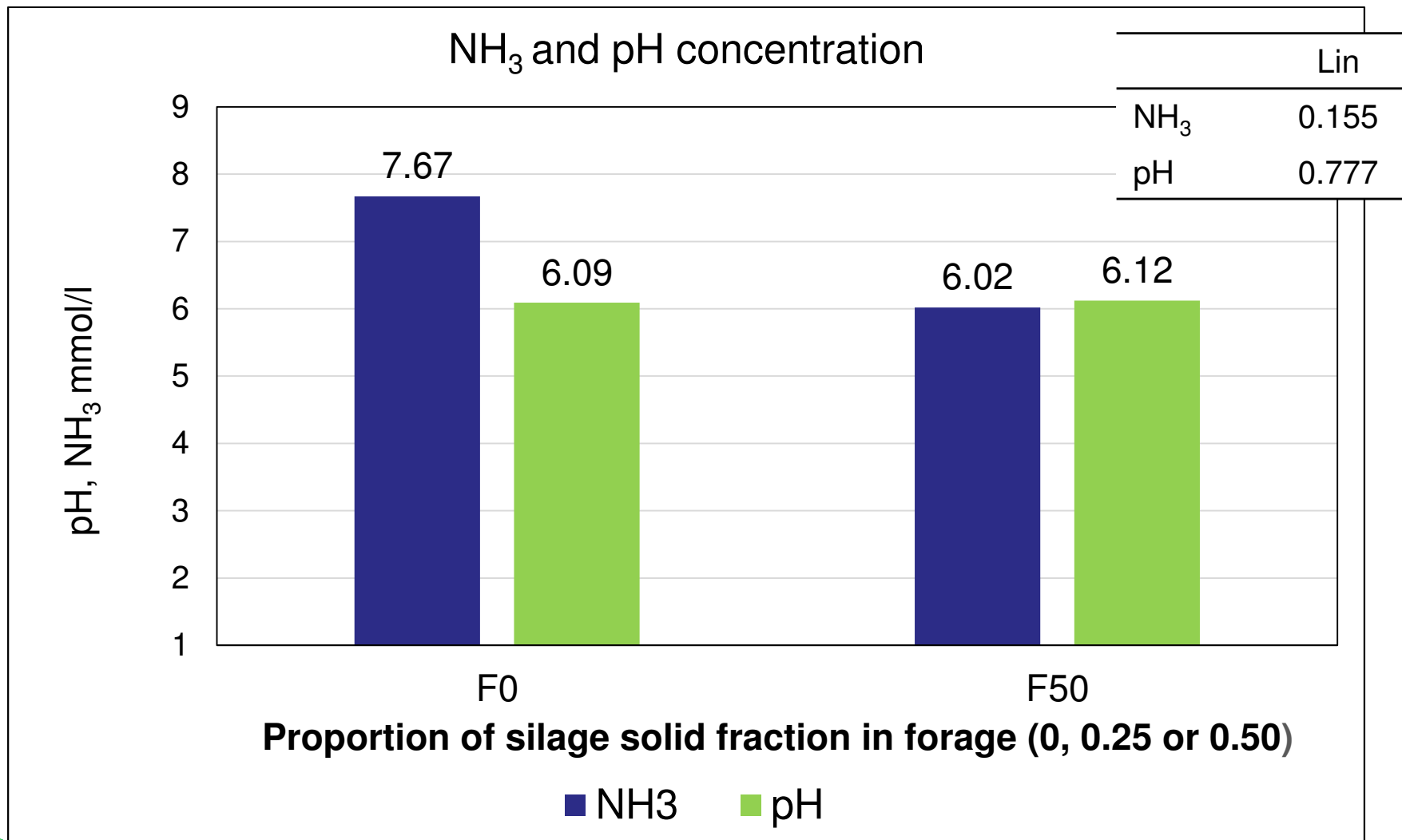
(N excreted in milk / N intake)



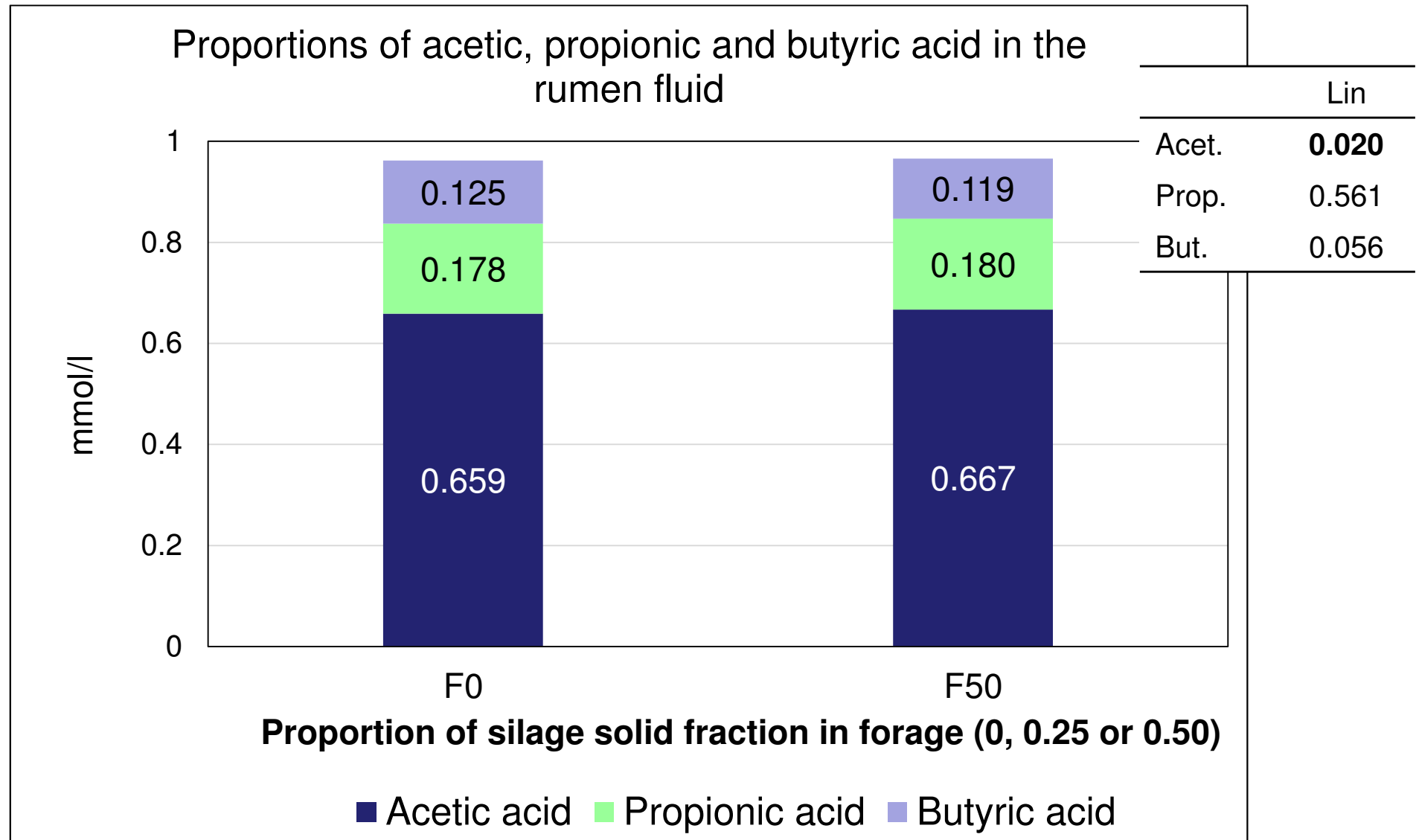
# Milk production efficiency resulted in highest values using the original silage.



**Ammonia N (NH<sub>3</sub>) concentration and pH in rumen fluid were not significantly different but changed numerically in a logical way.**



# Effects of silage solid fraction to the proportions of volatile fatty acids (VFA) were minor.



## Conclusions

- Dairy cows increased DM intake and reduced ECM production in response to increased silage solid fraction proportion in the forage  
=> Silage solid fraction was not as good as the original silage for high producing dairy cows.
- Farm scale biorefinery could be used to improve the utilization of silage  
=> **Solid fraction** to heifers and dry cows  
=> **Silage juice** to fortify total mix rations
- If there are higher added-value uses for silage liquid  
=> production potential of silage solid fraction for ruminant production is only marginally reduced

# Thank You



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