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Grass silage for biorefinery

Effect of additives on silage quality and liquid-solid separation of timothy and red clover silages

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Nordic Feed Science Conference
June 12-13 2018
www.slu.se/nordicfeedscienceconference

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outline

- General overview of the project
- Introduction
- Materials and Methods
- Results
- Conclusion
- What's coming up…

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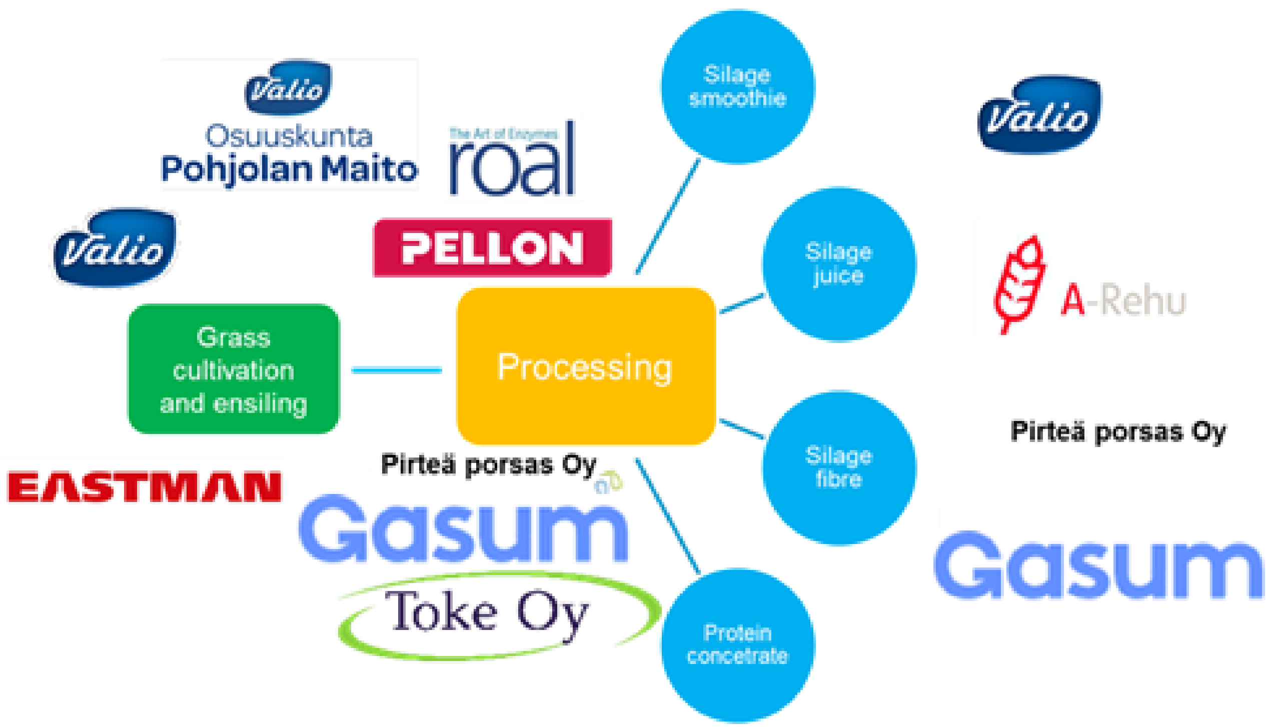
Innofeed project

Biorefining ensiled grass into inventive feed products

- Developing and testing methods to process grass silage into novel feeds
- Targets: to improve protein self sufficiency, profitability and sustainability of agricultural production in Finland
- Project is carried out during 2015-2018 by VTT and Luke
- Funding from TEKES and companies
  - A-Rehu
  - Gasum
  - Pohjolan Maito
  - Pellon
  - Pirteä Porsas
  - Roal
  - Eastman
  - Toholammin Kehitys
  - Valio



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Surplus grass biomass as raw material for green biorefineries

- Grass grows well in humid temperate areas with a capacity for high biomass production compared to annual crops
- Existing technology is available for its cultivation, harvesting and ensiling
- Due to its low lignin content, it is easier to process than wood or straw
- Grass offers a versatile raw material for feed and other purposes



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Potential to increase grass production from current level

- Increase production level per hectare of current grass fields
- Increase fields under intensive grass production (e.g. from fallow, peat lands)
- Traditional usage of grass as feed for ruminants & horses is not increasing - surplus grass available
- When preserved as silage, grass can be biorefined all year around

Photo: ©Luke / Marketta Rinne

Introduction

- Timothy and red clover → excellent potencial for biomass production (Boreal)
- Ensiling → all year round

Introduction

- First step of biorefinery → liquid-solid separation


Farm scale double screw press (Haarslev)


Lab. scale double screw press (Angel)

Lab scale

Farm scale


Farm scale single screw press (Pellon)

Used in this experiment


Lab. scale pneumatic press (Luke)

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Introduction

- First step of biorefinery → liquid-solid separation
- Silage additives ↑ fermentation ↓ losses (modify the characteristics of silage as a raw material for a green biorefinery)
- High correlation: silage quality & liquid yield and composition (Franco *et al*., 2018)
- Silage production system can be manipulated in order to prepare a feed that best meets the requirements of a particular green biorefinery process

The objective of the current work

- Evaluate the effect of additives on chemical composition and fermentation quality of timothy and red clover silages

- Silages were mechanically separated into liquid and solid fractions. Effects of additives and silage raw material quality (plant species and wilting) on the efficiency of the biorefinery process were also evaluated through assessing of yield and composition of the liquid fraction

materials and methods

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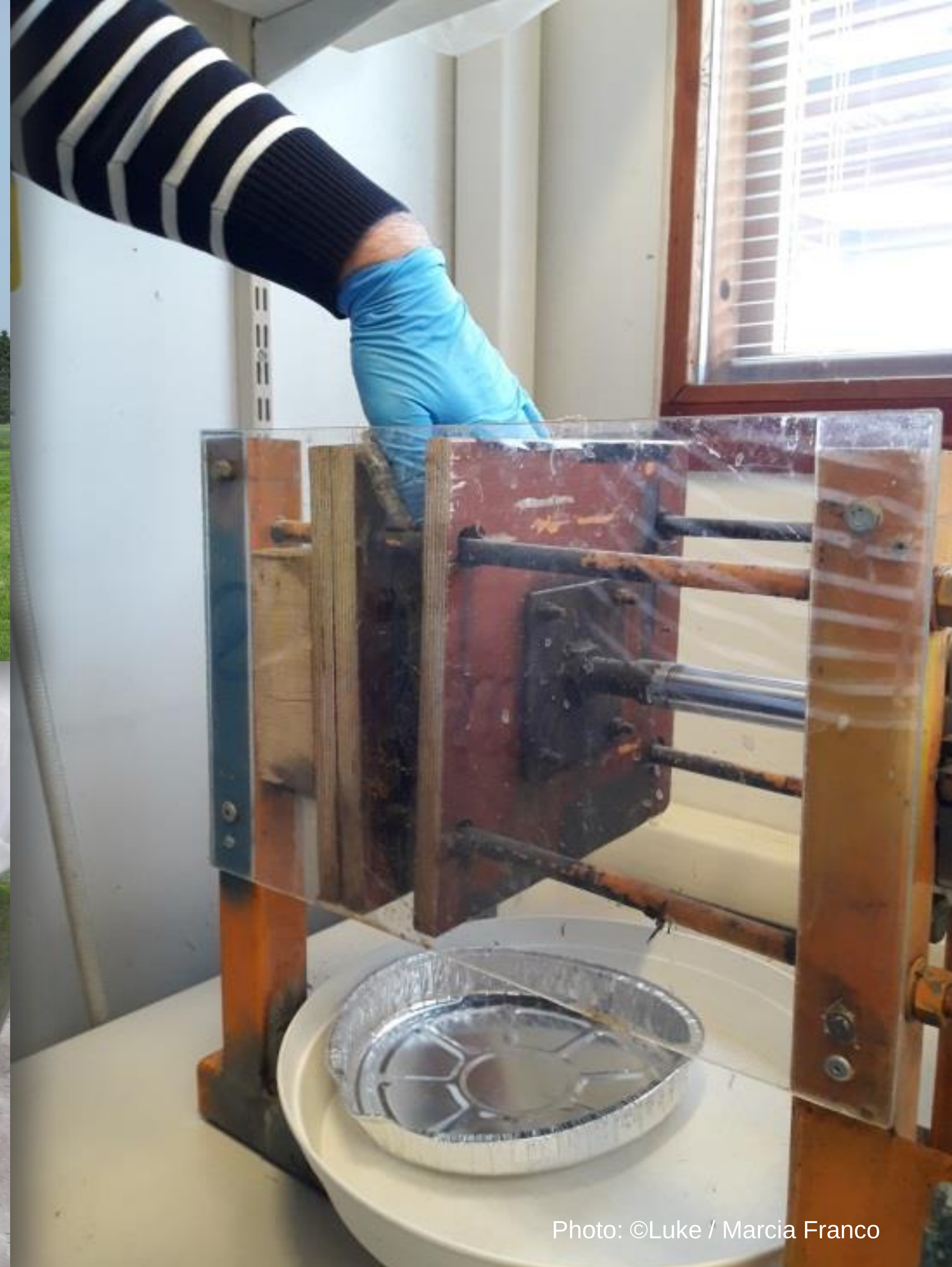

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Materials and Methods

Materials and Methods

Timothy and meadow fescue ensiled after:

- short (4 hours; G4)
- long (24 hours; G24) wilting period

Red clover (RC) ensiled after:

- 24 hours wilting

Materials and Methods


Photo: ©Luke / Marketta Rinne

<u>Timothy and meadow fescue</u> ensiled after:

- short (4 hours; G4)
- long (24 hours; G24) wilting period

<u>Red clover</u> (RC) ensiled after:

- 24 hours wilting

<u>Additive treatments</u>

- **Control** without additive (C)
- **Formic acid based additive – 5 l/t (FA)**
- **Lactic acid bacteria strains – 5 g/t (LAB)**

AIV 2 Plus Na
EASTMAN
Microbial Developments

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Experimental field – Timothy

Photos: ©Luke / Marketta Rinne

Timothy 4h and 24h wilted

Photos: ©Luke / Marketta Rinne

Experimental field – Red clover

Photos: ©Luke / Marketta Rinne

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Red clover 24h wilted

Red clover 24h wilted

Photos: ©Luke / Marketta Rinne

Opening the silos

Ensiling period of 111, 110 and 97 days (G4, G24 and RC)

Samples: chemical composition and fermentation products

Liquid-solid separation: pneumatic press (in-house built equipment; Luke)

Photos: ©Luke / Marketta Rinne

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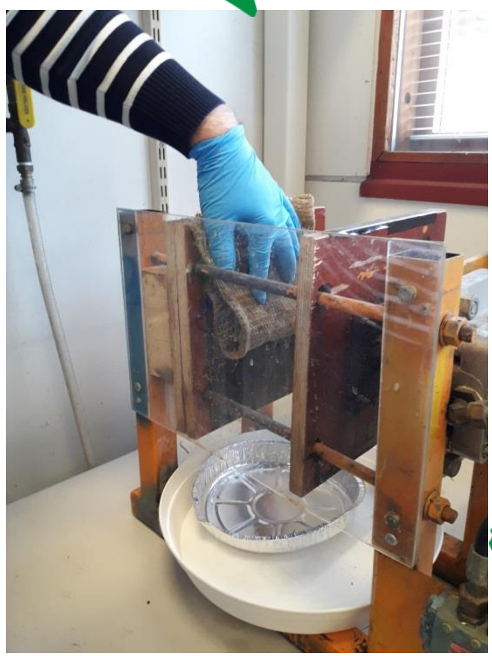
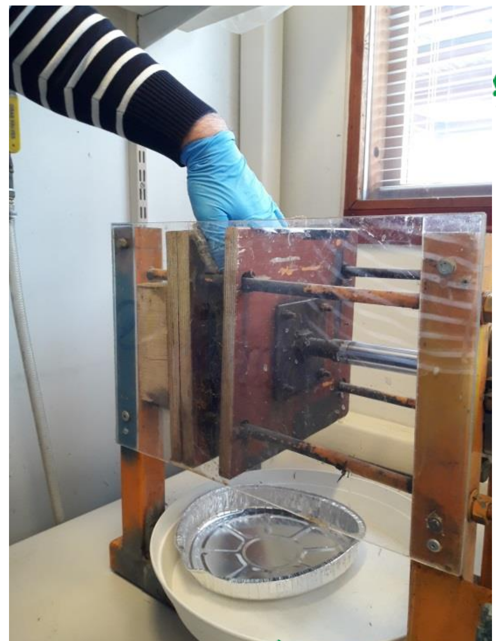
Liquid-solid separation: pneumatic press (in-house built equipment; Luke)





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Data analysis

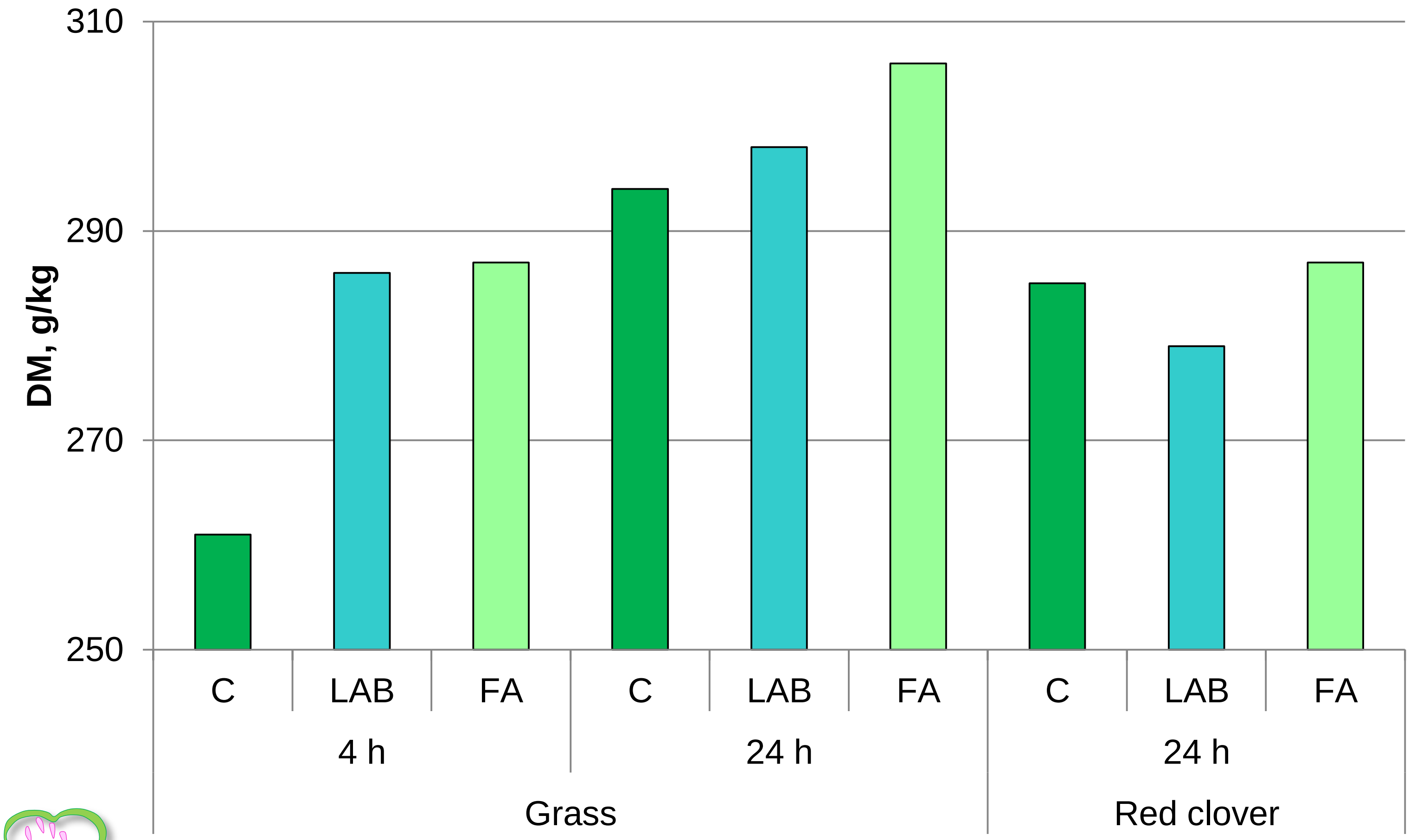
- ✓ **MIXED** procedure of SAS at 5% of probability
- ✓ **Timothy**: additive, wilting period effects and their interaction
- ✓ **Red clover**: additive effect
- ✓ **Overall interaction effect**: additive * forage species


Results

Chemical composition of timothy and meadow fescue (4 and 24 hours wilting; G4 and G24) and red clover (RC) herbage prior to ensiling

	G4	G24	RC
Dry matter (DM), g/kg	290	298	285
Buffering capacity	6.40	6.54	10.10
In DM, g/kg			
Ash	82	88	101
Crude protein	98	103	197
Water soluble carbohydrates	153	109	89
Neutral detergent fibre	537	563	334
D-value	700	681	677
Organic matter digestibility	0.762	0.746	0.753
Metabolizable energy, MJ/kg DM	11.2	10.9	10.8

Dry matter (g/kg) of grass and red clover silages treated with additives

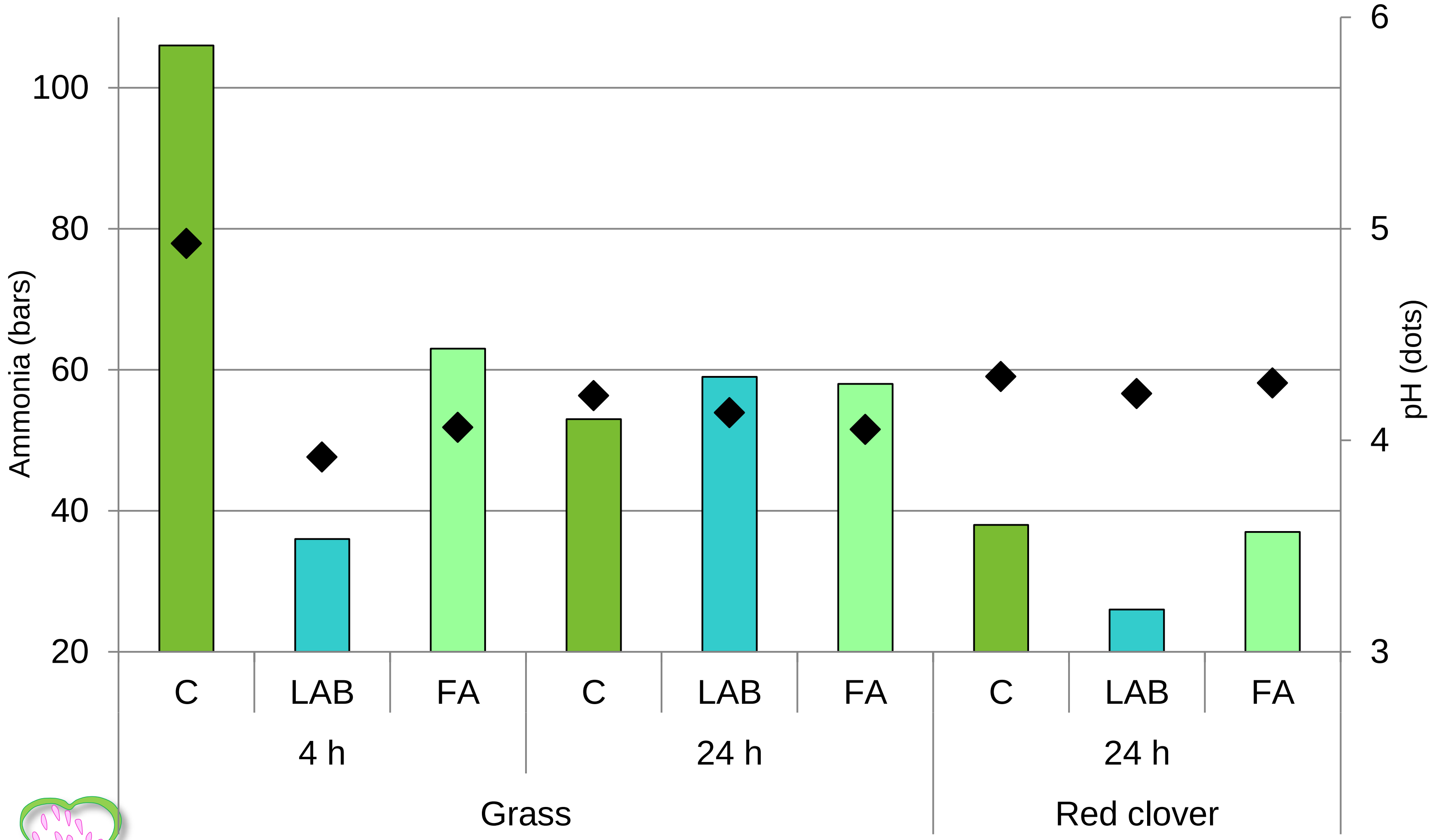


Grass
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add = 0.634

Add*species = 0.021

Ammonia (g/kg N) and pH of grass and red clover silages treated with additives



Ammonia

Grass

Add < 0.001

Wilt < 0.001

Add*Wilt < 0.001

Red clover

Add < 0.001

Add*species < 0.001

pH

Grass

Add < 0.001

Wilt = 0.004

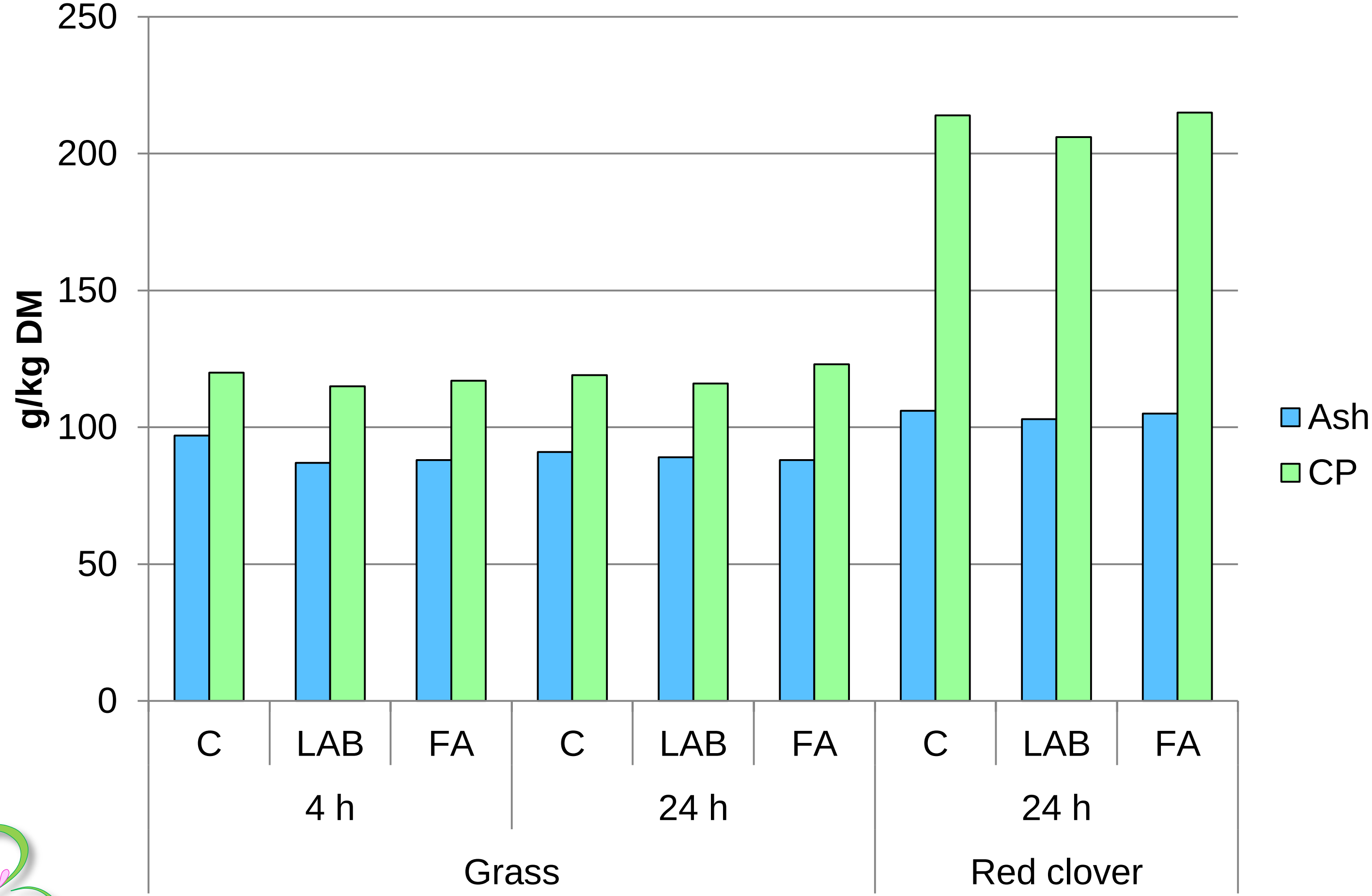
Add*Wilt < 0.001

Red clover

Add = 0.024

Add*species = 0.012

<u>Ash and crude protein</u> (g/kg DM) of grass and red clover silages treated with additives



<u>Ash</u>
<u>Grass</u>
Add < 0.001
Wilt = 0.062
Add*Wilt < 0.001

<u>Red clover</u>
Add = 0.071

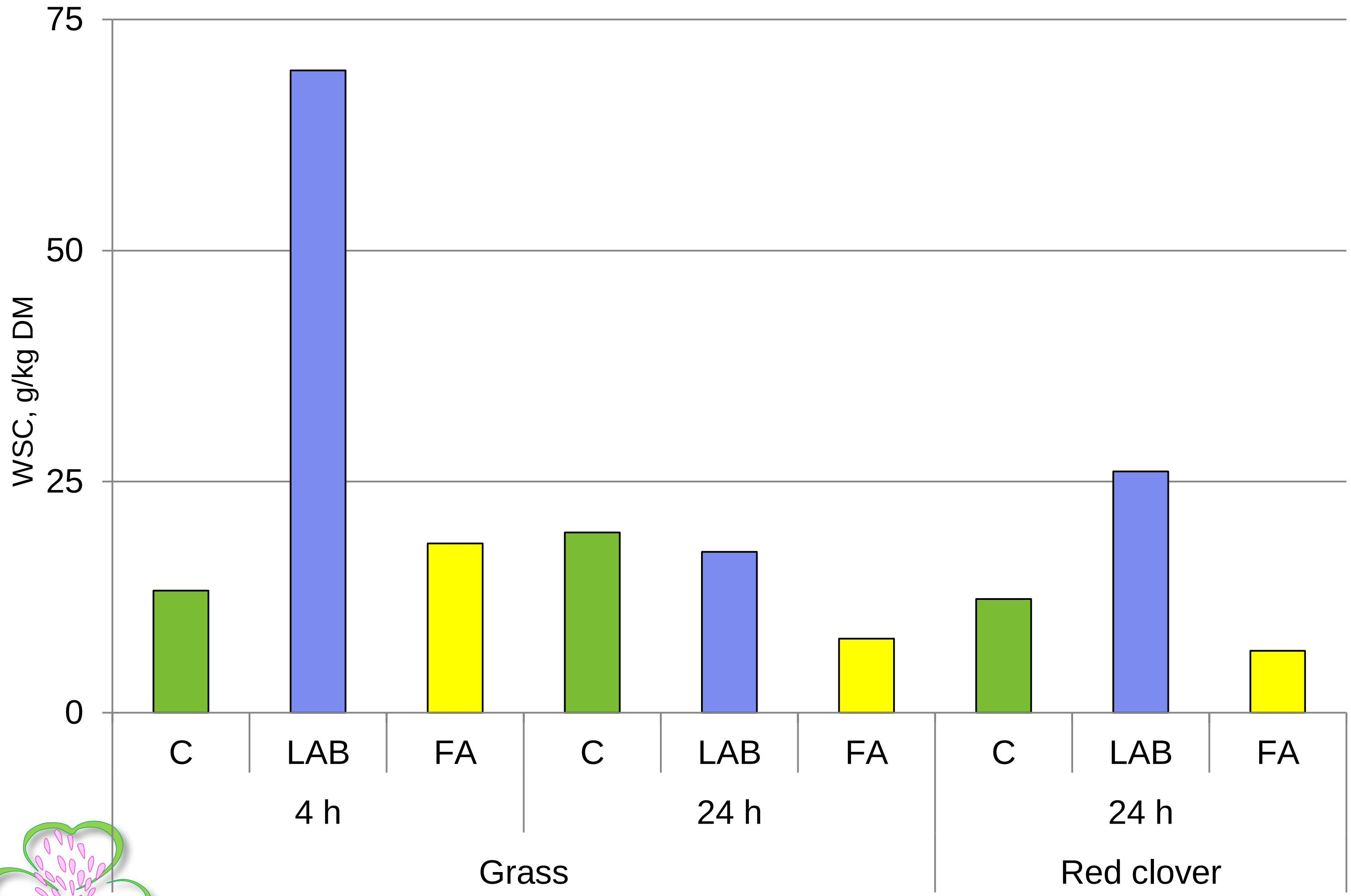
Add*species = 0.901

<u>Crude protein</u>
<u>Grass</u>
Add = 0.134
Wilt = 0.097
Add*Wilt = 0.056

<u>Red clover</u>
Add = 0.069

Add*species = 0.104

Water soluble carbohydrate (g/kg DM) of grass and red clover silages treated with additives

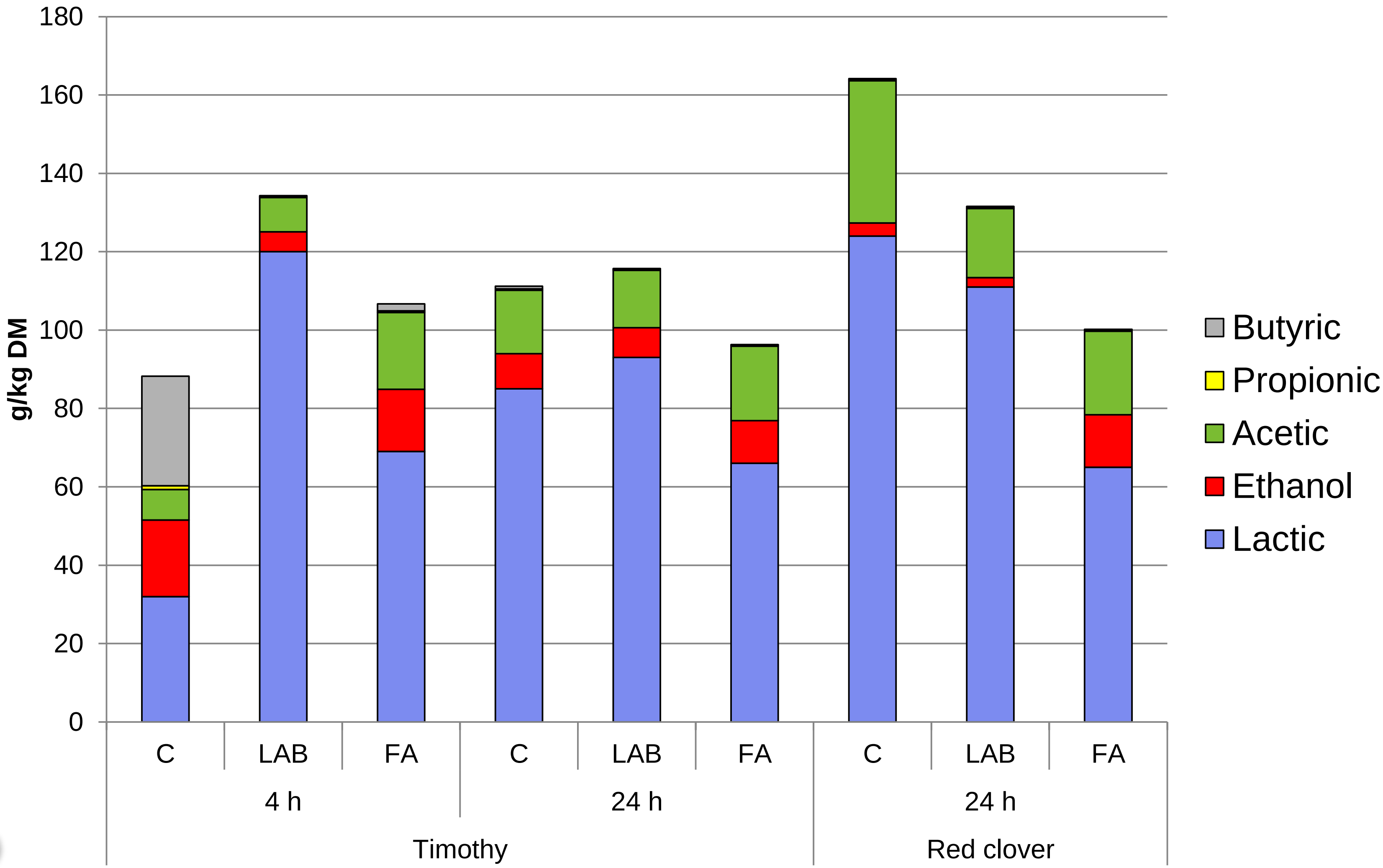


<u>Grass</u>
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

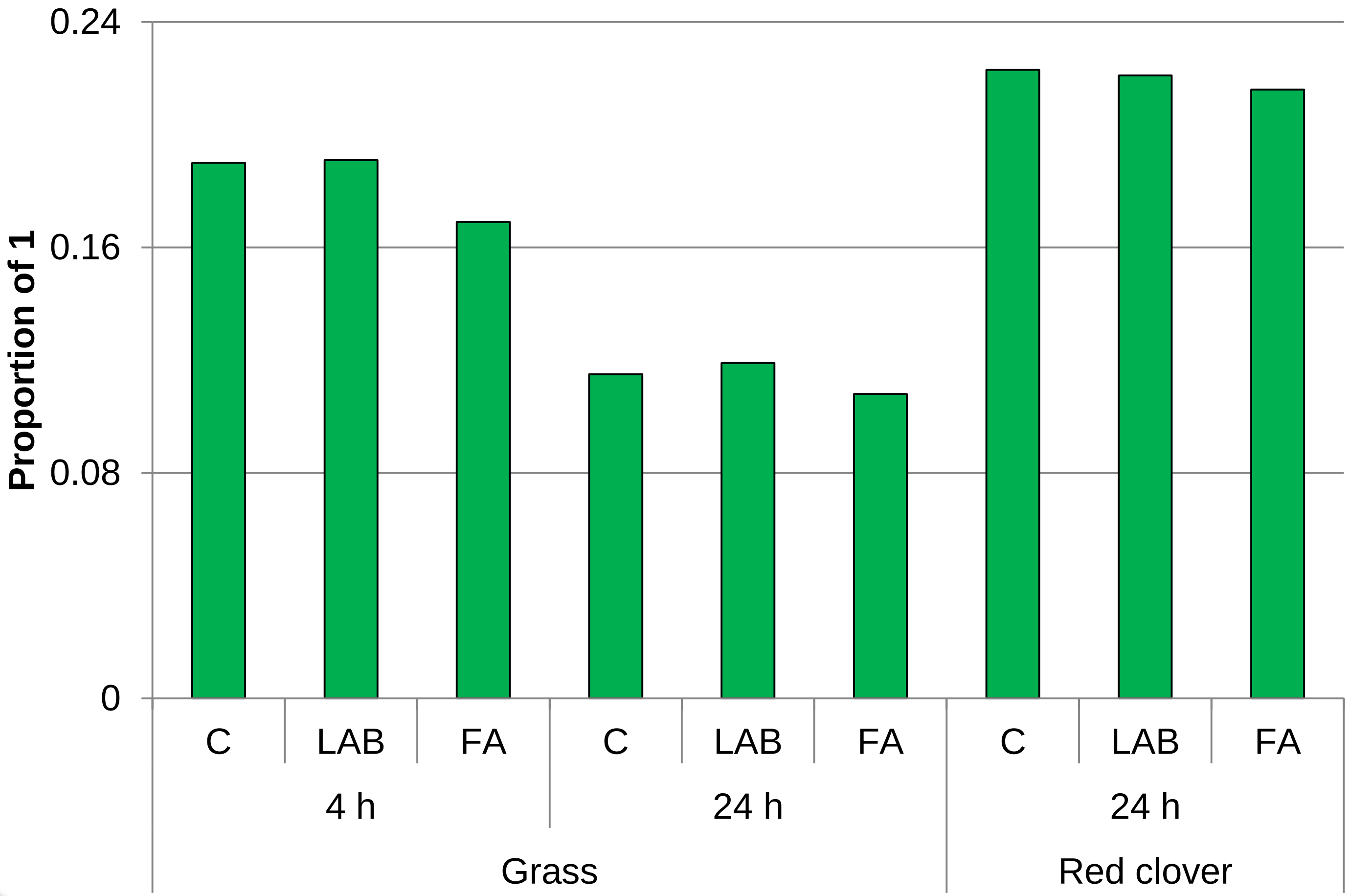
<u>Red clover</u>
Add = 0.121

Add*species = 0.010

Fermentation quality of grass and red clover silages treated with additives



Yield of liquid-solid separation of grass and red clover silages treated with additives

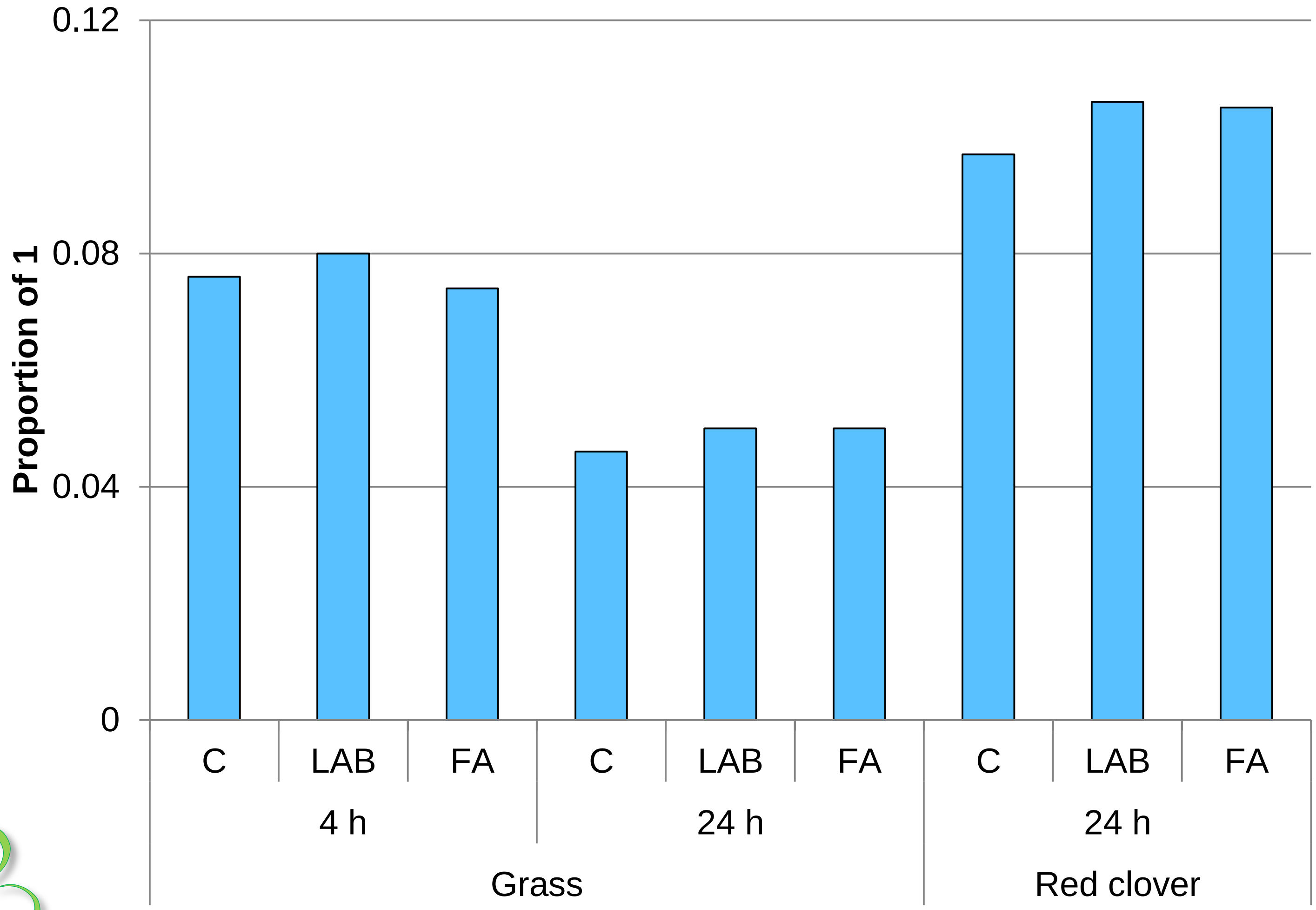


Grass
Add = 0.445
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add = 0.121

Add*species = 0.010

Dry matter retained in liquid of liquid-solid separation of grass and red clover silages treated with additives

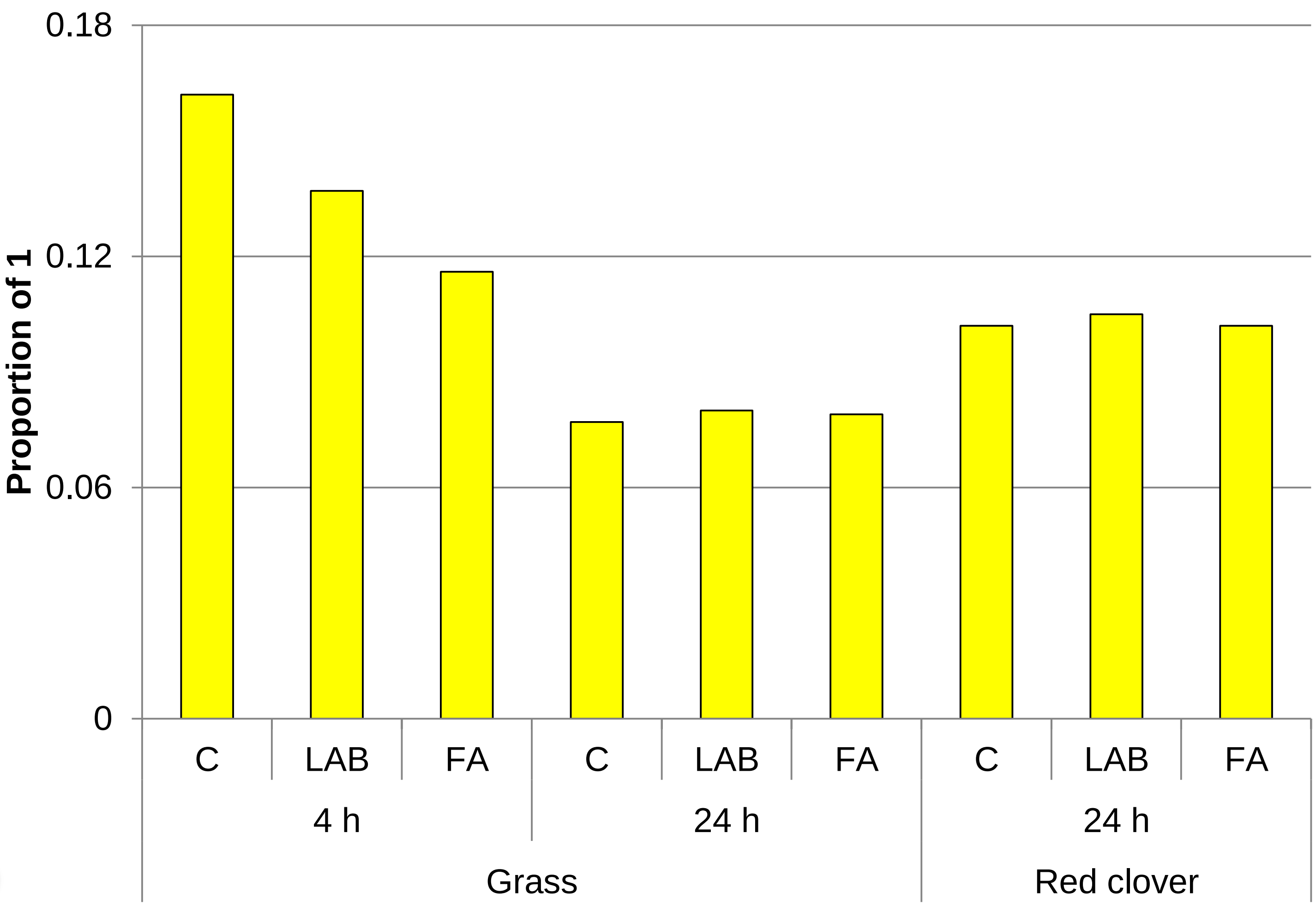


Grass
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add < 0.001

Add*species < 0.001

Crude protein retained in liquid of liquid-solid separation of grass and red clover silages treated with additives

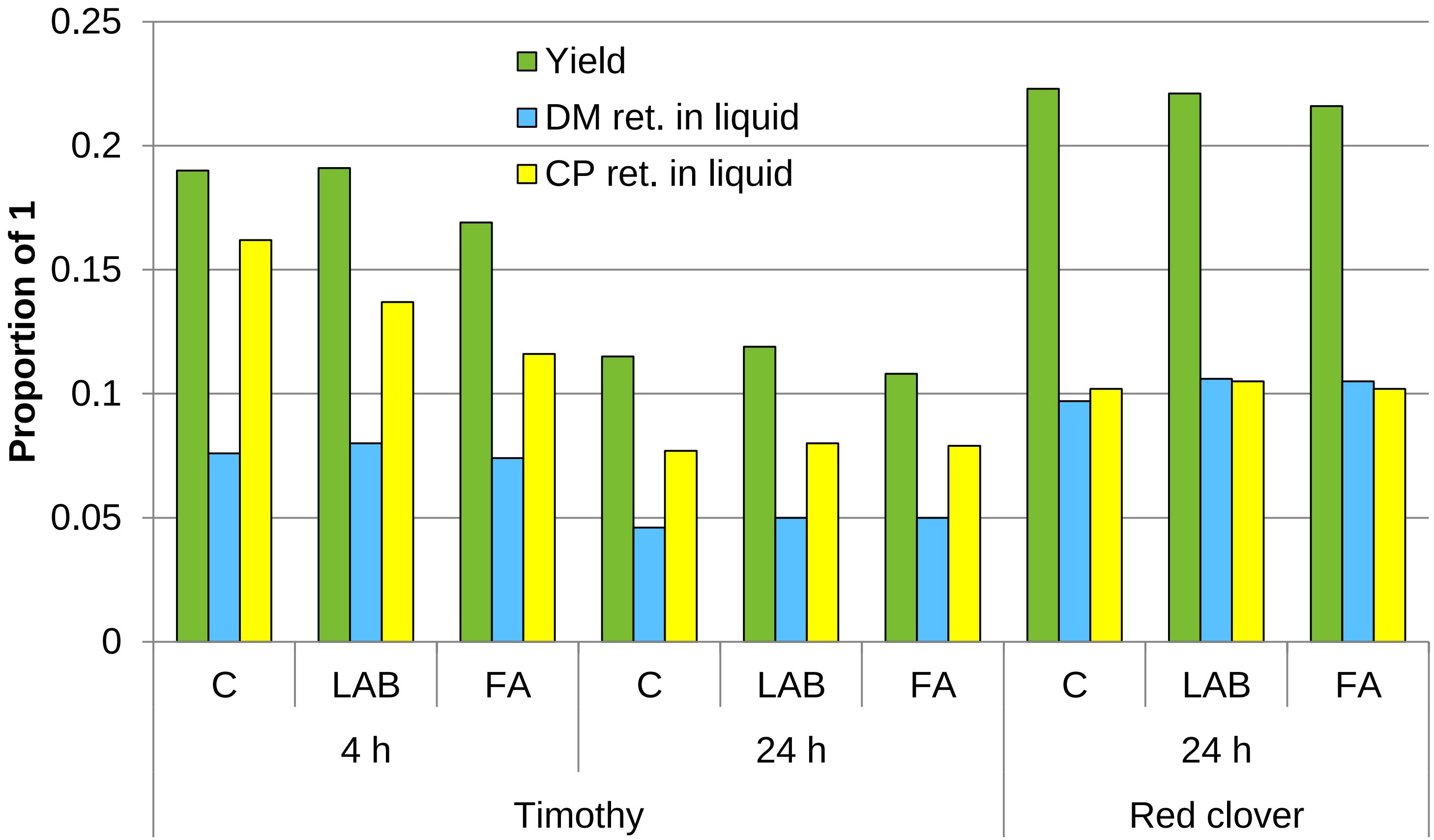


Grass
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add < 0.001

Add*species < 0.001

Yield and retained compounds of liquid-solid separation of grass and red clover silages treated with additives



Yield
Grass
Add = 0.445
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add = 0.121

Add*species = 0.010

DM ret. in liquid
Grass
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add < 0.001

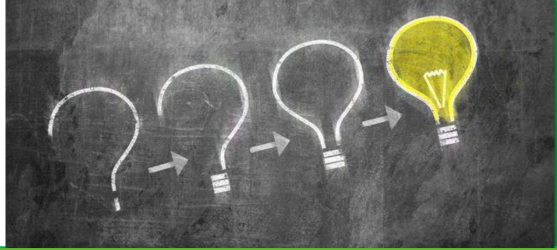
Add*species < 0.001

CP ret. in liquid
Grass
Add < 0.001
Wilt < 0.001
Add*Wilt < 0.001

Red clover
Add < 0.001

Add*species < 0.001

Conclusion



- ✓ Formic acid and lactic acid bacteria strains as additives on grass and red clover forages positively impacted chemical composition and fermentation quality of the silages
- ✓ Chemical composition influenced liquid yield in liquid-solid separation of grass silages while no effect of additives on liquid yield was observed
- ✓ Shorter wilting period resulted in higher crude protein retained in liquid
- ✓ Additives increased crude protein retained in liquid for red clover

WHAT'S COMING UP? 2018

- Savonen, O., Franco, M., Stefański, T., Mäntysaari, P., Kuoppala K. & Rinne, M. Grass silage from biorefinery - Dairy cow responses to diets based on solid fraction of grass silage.

- Stefański, T., Franco, M., Kautto, O., Jalava, T., Winquist, E. & Rinne, M. Grass silage for biorefinery – Separation efficiency and aerobic stability of silage and solid fraction.

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Grass for biorefinery

Dairy cow responses to diets based on solid fraction of grass silage

Outi Savonen, Marcia Franco, Tomasz Stefański, Päivi Mäntysaari, Kaisa Kuoppala & Marketta Rinne

Natural Resources Institute Finland (Luke), Jokioinen, Finland

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Nordic Feed Science Conference

June 12-13 2018

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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 fraction: 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 pressing methods

- Farm scale twin screw press (FTS; Haarslev Industries A/S, Søndersø, Denmark)
- Laboratory scale twin screw press (LTS; Angel Juicer 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 l/ton (FAPA), Propionic acid based preservative at 3 l/ton (PA)

Aerobic stability measurement

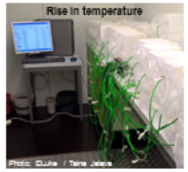

Table 1 Chemical composition of original silages, and solid and liquid fractions.

	FTS			LTS			LPP	
	Silage	Solid	Liquid	Silage	Solid	Liquid	Solid	Liquid
Dry matter, g/kg	204	430	63	214	497	85	310	70
In dry matter, g/kg								
Ash	71	42	197	70	43	183	55	229
Crude protein	142	107	279	144	99	262	118	271
Neutral detergent fibre	609	727	-	609	Nd*	-	Nd*	-
Ammonia-N, g/kg N	30	16	3	30	Nd*	Nd*	Nd*	Nd*
Organic matter digestibility	724	695	-	724	Nd	-	Nd	-

FTS: farm scale twin screw press; LTS: laboratory scale twin screw press; LPP: laboratory scale pneumatic press. *Not determined.

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

	FTS	LTS	LPP	SEM
Liquid yield	0.576^{a}	0.601^{a}	0.345^{b}	0.0218
Liquid dry matter (DM), g/kg	71^{b}	84^{a}	69^{b}	1.4
In liquid DM, g/kg				
Crude protein (CP)	270^{a}	263^{a}	271^{a}	1.2
Ash	189^{a}	178^{a}	218^{a}	11.7
Amount retained in liquid as proportion of original silage				
DM	0.193^{b}	0.237^{a}	0.112^{c}	0.0056
CP	0.361^{a}	0.422^{a}	0.209^{b}	0.0112
Ash	0.535^{a}	0.606^{a}	0.351^{b}	0.0308

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

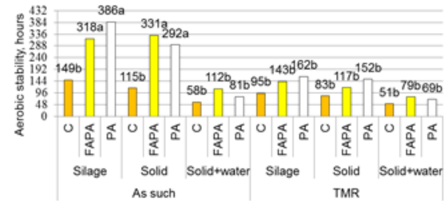

Figure 1 Effect of preservatives on aerobic stability assessed through increasing in temperature. Preservative $P<0.001$; Silage vs Solid used as such $P=0.060$; Silage vs Solid in TMR $P=0.417$; Silage as such vs Silage in TMR $P<0.001$; Solid as such vs Solid in TMR $P<0.001$; Silage vs Solid+water as such $P<0.001$; Silage vs Solid+water in TMR $P=0.001$; As such vs TMR $P<0.001$. Means without same letter differ ($P<0.05$).

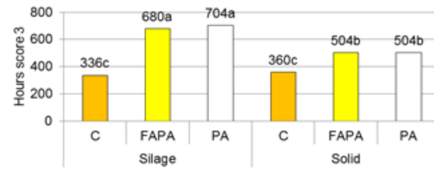

Figure 2 Effect of preservatives on aerobic stability through visual inspection. Silage vs Solid $P<0.001$; Preservative in silage $P<0.001$; Preservative in solid $P<0.001$; Preservative $P<0.001$; Raw material*Preservative $P<0.001$; FAPA vs PA $P=0.458$. Means without same letter differ ($P<0.05$).

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.

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WHAT'S COMING UP?

2018

Nordic Feed Science Conference
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- Savonen, O., Franco, M., Stefański, T., Mäntysaari, P., Kuoppala K. & Rinne, M. Grass silage from biorefinery - Dairy cow responses to diets based on solid fraction of grass silage.
- Stefański, T., Franco, M., Kautto, O., Jalava, T., Winquist, E. & Rinne, M. Grass silage for biorefinery – Separation efficiency and aerobic stability of silage and solid fraction.

EGF 2018
17TH - 21ST JUNE 2018 | CORK, IRELAND

- Rinne, M., Jalava, T., Stefanski, T., Kuoppala, K., Timonen, P., Winquist, E. & Siika-aho, M. Optimizing grass silage quality for green biorefineries.

XVIII ISC 2018

- Rinne, M., Keto, L., Siljander-Rasi, H., Stefanski, T. & Winquist, E. Grass silage for biorefinery – Palatability of silage juice for growing pigs and dairy cows.
- Rinne, M., Timonen, P., Stefanski, T., Franco, M., Winquist, E. & Siika-aho, M. Grass silage for biorefinery – Effects of type of additive and separation method.
- Franco, M., Winquist, E. & Rinne, M. Grass silage for biorefinery – A meta-analysis of silage factors affecting liquid-solid separation.

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More information about Innofeed project

- Project home page:

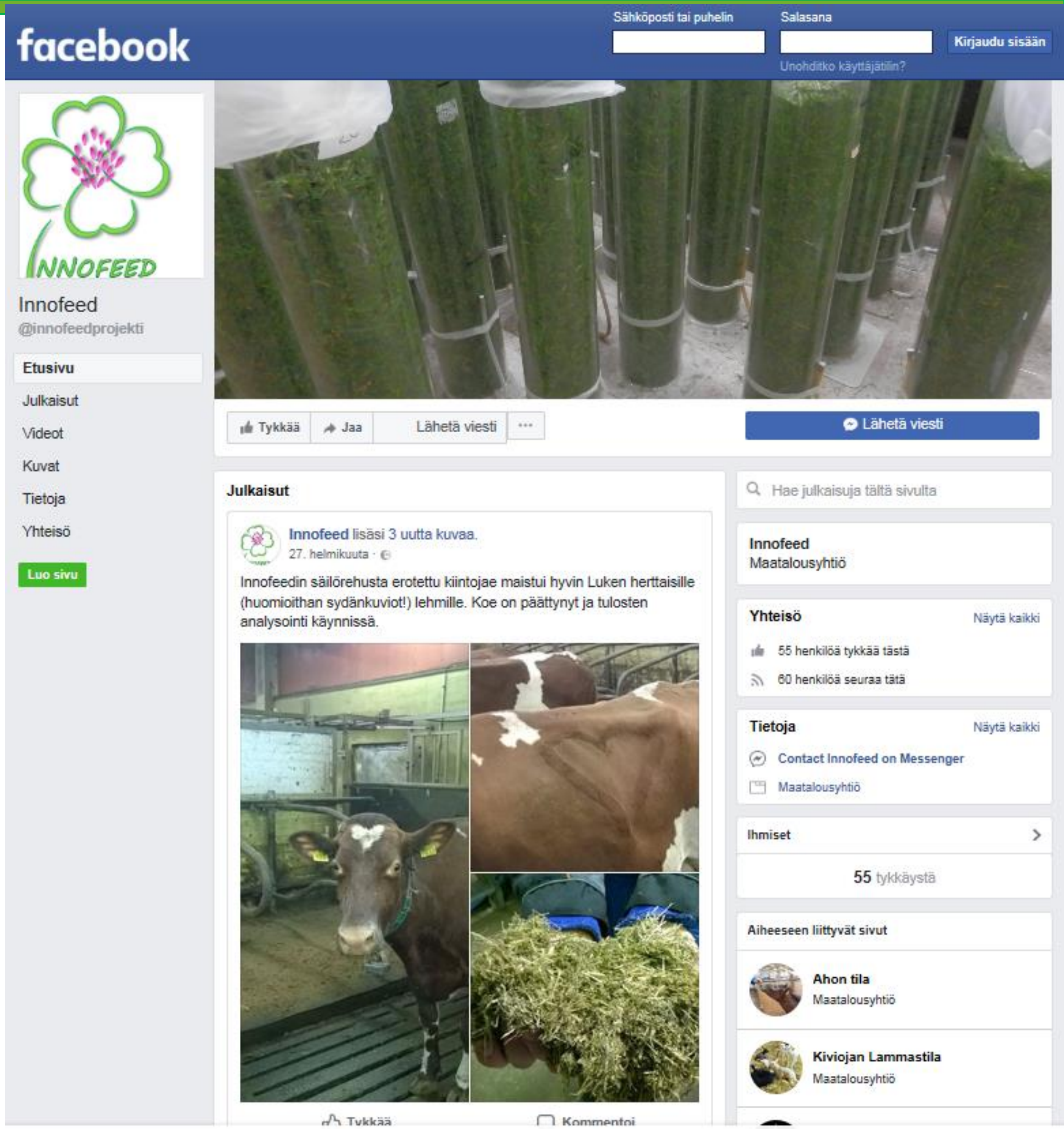
  https://www.ibcfinland.fi/projects/innofeed/

- Facebook:

  https://www.facebook.com/innofeedprojekti

- Press release:

  http://www.vttresearch.com/media/news/biorefineries-turn-grass-into-new-feed-products



Thank you!

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