Grass silage for biorefinery

A meta-analysis of silage factors affecting liquid-solid separation

XVIII ISC 2018

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Innofeed project

Biorefining ensiled grass into inventive feed products

Ensiled grass

Potential to be biorefined

Variety of innovative products

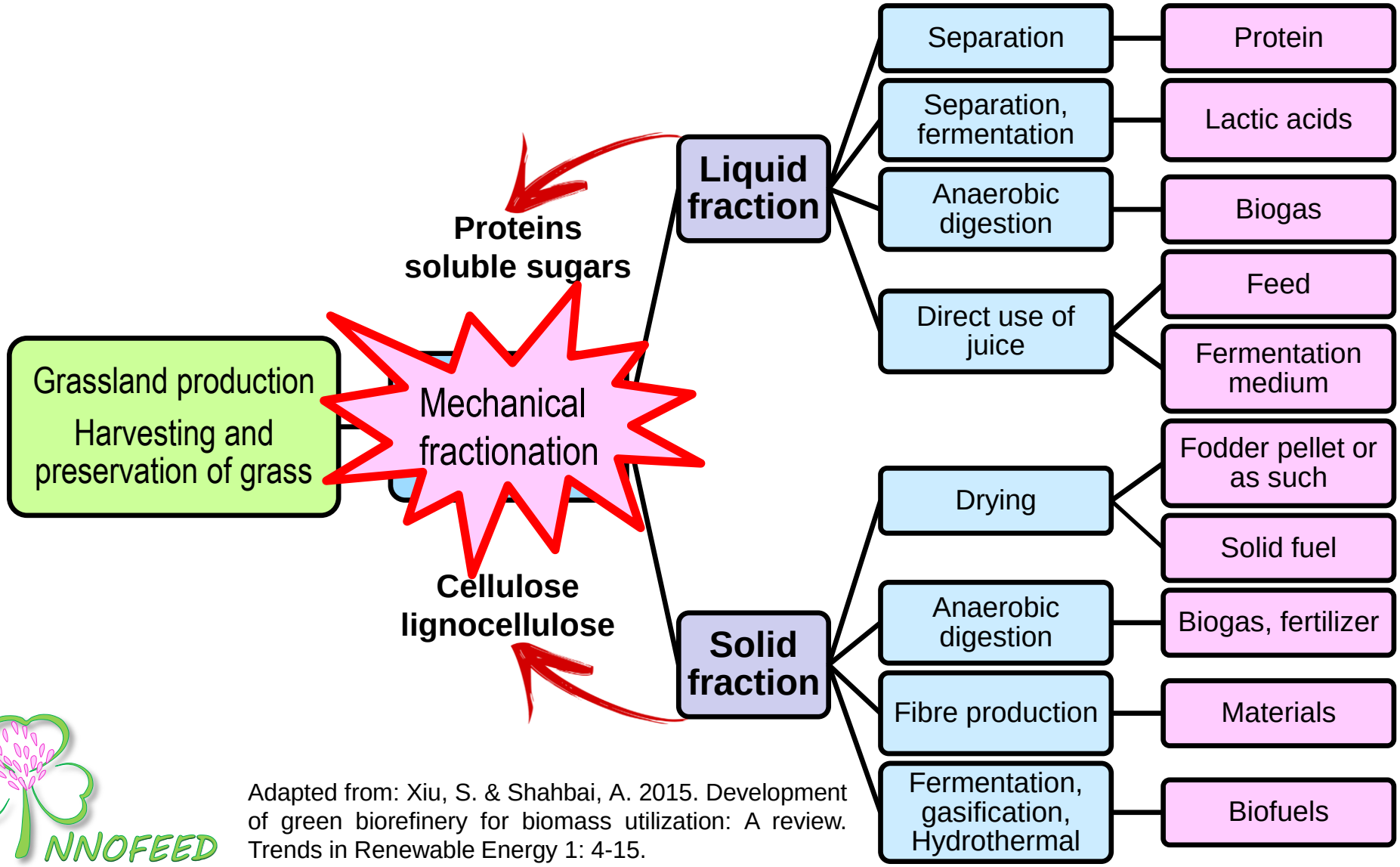
Silage → All year round

Improves the opportunity of a more efficient and sustainable use of green biomass

Photo: ©Luke / Marketta Rinne

Concept of a green biorefinery

Green biorefinery can produce multiple end products and include various processes



Adapted from: Xiu, S. & Shahbai, A. 2015. Development of green biorefinery for biomass utilization: A review. Trends in Renewable Energy 1: 4-15.

The objective of the current work

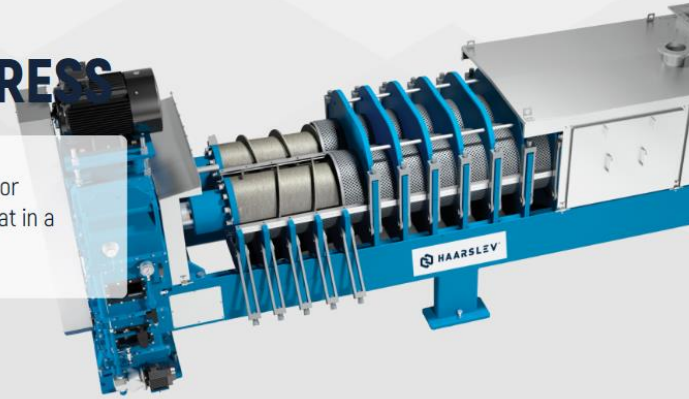
Evaluate the effect of silage quality on liquid yield, liquid composition and retained compounds in liquid through a meta-analytical approach

materials and methods

Photo: ©Luke / Marketta Rinne

TWIN SCREW PRESS

The Haarslev Twin Screw Press is used for pressing liquids from cooked fish or meat in a wet rendering process.



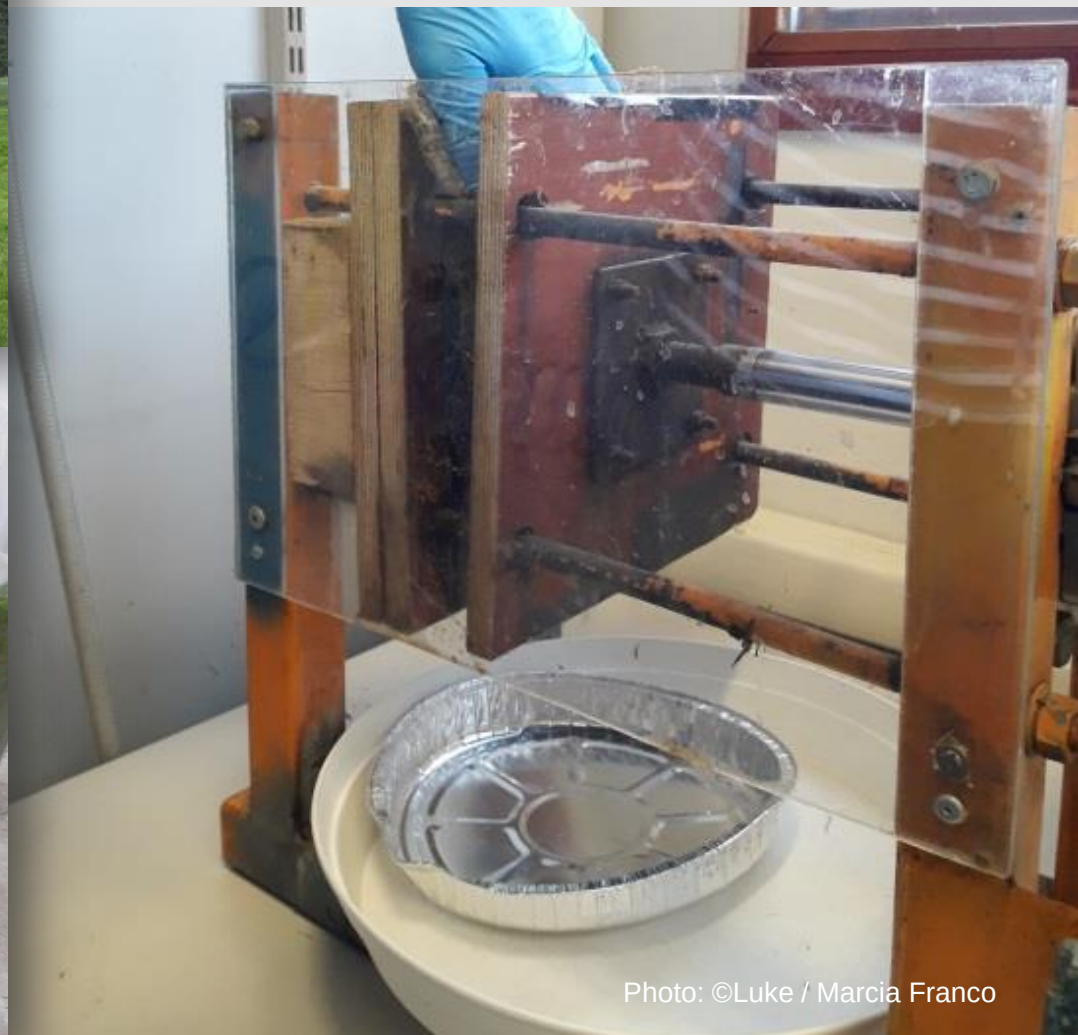
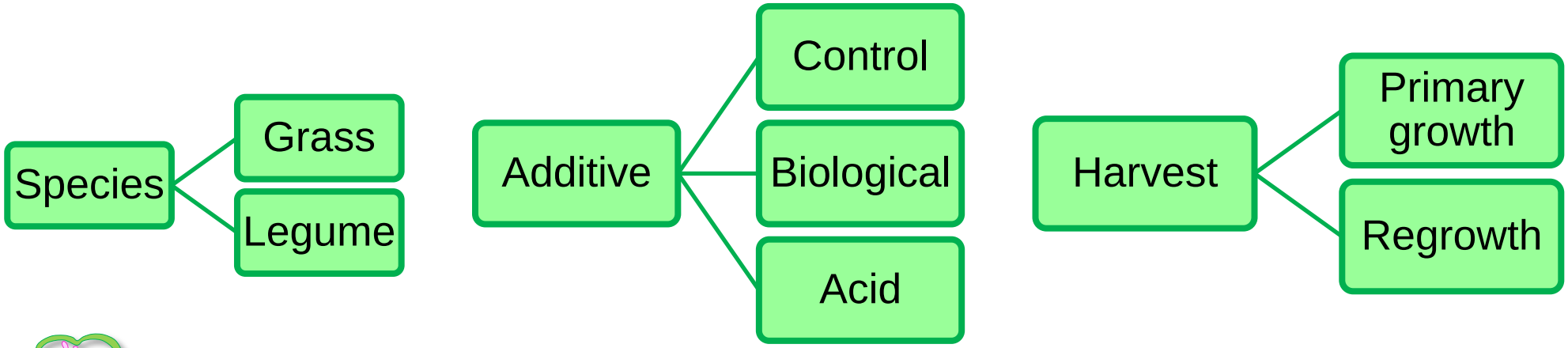


Photo: ©Luke / Marcia Franco

Materials and Methods

- 17 studies → 32 mean values of silage that was separated into liquid and solid fractions
- **<u>Meta-analysis:</u>** how silage characteristics affect liquid yield, chemical composition and compounds retained in the liquid fraction



Materials and Methods

First step of biorefinery → liquid-solid separation

Farm scale

1. Farm scale twin screw press (Haarslev)

2. Farm scale single screw press (Pellon)

Photos: ©Luke / M. Franco & M. Rinne

Materials and Methods

First step of biorefinery → liquid-solid separation

Laboratory scale

3. Laboratory scale twin screw press (Angel Juicer)

4. Laboratory scale pneumatic press (Luke)

Photos: ©Luke / M. Franco & T. Stefański

Materials and Methods

- Chemical composition and *in vitro* organic matter digestibility (IVOMD)
- **Response variables:** liquid yield, composition and retained compounds
- Silage characteristics with highest correlation to liquid yield
- Equations were developed using a mixed model regression analysis (individual experiments = random effect)
- **Adjustment:** 1. Coefficient of determination (R^2)

  2. Akaike's information criterion (AIC)

  3. Root mean square error (RMSE)

The Results

Photo: ©Eeva Saarisalo

Descriptive statistics of the data set for liquid-solid separation

Mean: 321 g kg^{-1}
Salo *et al.*, 2014

Variable	n	Mean	SD	Min	Max
Regard silage					
Silage DM, g kg^{-1}	32	232	44.6	138	320
Silage ash, g kg^{-1} DM	32	87	22.1	52	118
Silage CP, g kg^{-1} DM	32	142	29.6	84	211
Silage NDF, g kg^{-1} DM	25	471	61.5	342	586
Silage IVOMD, g kg^{-1} OM	25	740	38.9	646	804
Regard liquid					
Liquid yield	46	0.425	0.1509	0.179	0.702
Liquid DM, g kg^{-1} DM	46	98	31	33	149
Liquid CP, g kg^{-1} DM	46	190	62.1	84	331
DM retained in liquid	46	0.184	0.0886	0.011	0.379
CP retained in liquid	43	0.248	0.1379	0.073	0.736

Pearson correlation coefficients between liquid yield and silage quality for different liquid-solid separation methods

Variable	Liquid yield correlation coefficients			
	LPP	FSS	FTS	LTS
Silage DM, g kg^{-1}	**-0.58**	**-0.95**	-0.27	**-0.86**
Silage ash, g kg^{-1} DM	-0.25	0.46	0.87	0.12
Silage CP, g kg^{-1} DM	0.38	-0.03	0.59	0.54
Silage NDF, g kg^{-1} DM	-0.49	0.61	-0.86	-
Silage IVOMD, g kg^{-1} OM	0.15	-0.18	**0.95**	-

First

Second

LPP: laboratory scale pneumatic press
FSS: farm scale single screw press
FTS: farm scale twin screw press
LTS: laboratory scale twin screw press
Correlation coefficients **bolded** are significant at 5% probability

Effect of silage quality on prediction of liquid yield, composition and retained compounds in liquid

Laboratory Scale Pneumatic Press (LPP; n = 22)

Y = dep variable	X = indep variables	α	β_1	β_2	AIC	R^2	RMSE
Liquid yield	X_1 = DM	0.834	**-0.0022**		-43.1	0.31	0.08
	X_1 = DM; X_2 = NDF	1.21	**-0.0028**	-0.0005	-3.2	0.57	0.08
Liquid DM	X_1 = DM (r = 0.83; P<0.01)	31.0	**0.3346**		163	0.68	18.9
	X_1 = DM; X_2 = IVOMD	49.9	**0.2946**	-0.0045	88.2	0.42	9.43
DM retained in liquid	X_1 = NDF	0.665	**-0.0011**		-13.7	0.41	0.06
	X_1 = NDF; X_2 = IVOMD	-0.0589	**-0.001**	0.0009	-3.6	0.53	0.05
Liquid CP	X_1 = DM (r = 0.41; P<0.07)	148	0.2680		218	0.12	65.4
	X_1 = DM; X_2 = NDF	426	0.7933	-0.893	117.5	-0.06	60.6
CP retained in liquid	X_1 = NDF	0.695	-0.0011		-9.2	0.19	0.07
	X_1 = NDF; X_2 = CP	0.876	-0.0013	-0.0005	3.9	0.10	0.08

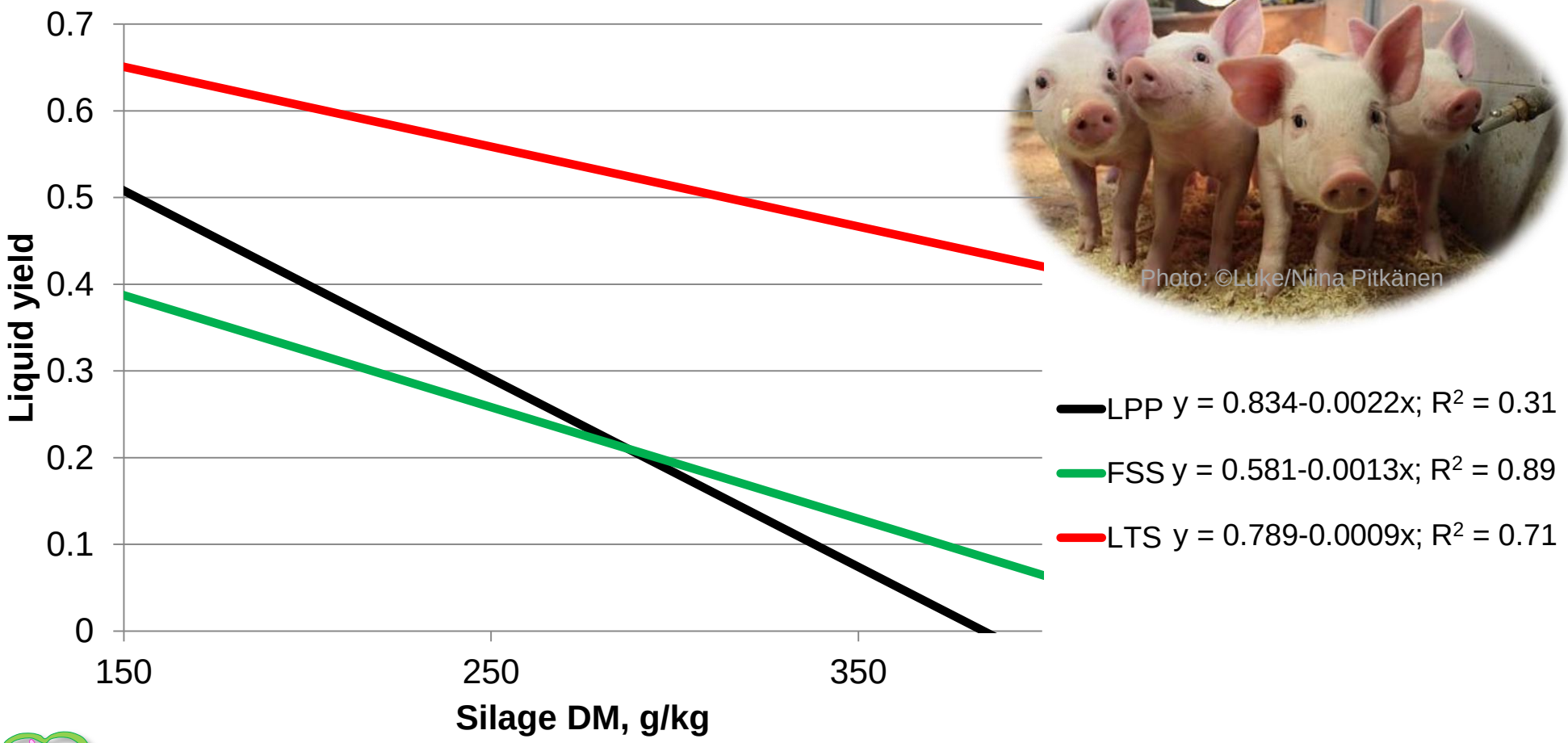
Coefficients **bolded** are significant at 5% probability

Effect of silage quality on prediction of liquid yield, composition and retained compounds in liquid for different separation methods

Press	Y = dep variable	X = indep variables	α	β_1	β_2	AIC	R^2	RMSE
FSS (n = 10)	Liquid yield	X_1 = DM	0.581	**-0.0013**		-10.9	0.89	0.02
		X_1 = DM; X_2 = NDF	0.478	**-0.0011**	0.0001	3.1	0.87	0.02
FTS (n = 4)	Liquid yield	X_1 = IVOMD	-4.14	**0.0059**		-4.2	0.84	0.02
		X_1 = IVOMD; X_2 = NDF	-4.27	**0.0061**	-0.0002	4.5	0.92	0.01
LTS (n = 11)	Liquid yield	X_1 = DM	0.789	**-0.0009**		-22.5	0.71	0.03
		X_1 = DM; X_2 = CP	0.865	-0.0012	-0.0002	-8.9	0.68	0.04

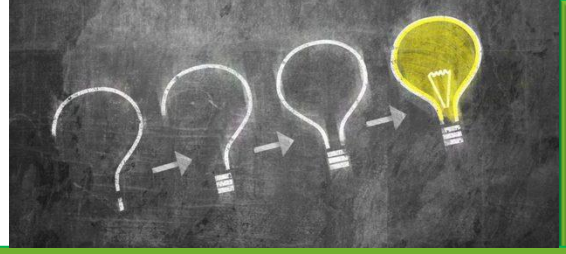
FSS; farm scale single screw press
FTS: farm scale twin screw press
LTS: laboratory scale twin screw press
Coefficients **bolded** are significant at 5% probability

Prediction of liquid yield using regression equations based on silage dry matter for different separation methods



LPP: laboratory scale pneumatic press
FSS: farm scale single screw press
LTS: laboratory scale twin screw press

Conclusion



- ✓ The high correlation between silage quality and liquid yield and composition provides prospective to predict the biorefinery potential of a particular silage batch based on these equations
- ✓ This information can also be used to modify the silage production systems so that they best meet the requirements of a green biorefinery process

More information about Innofeed project

- **Project home page:**

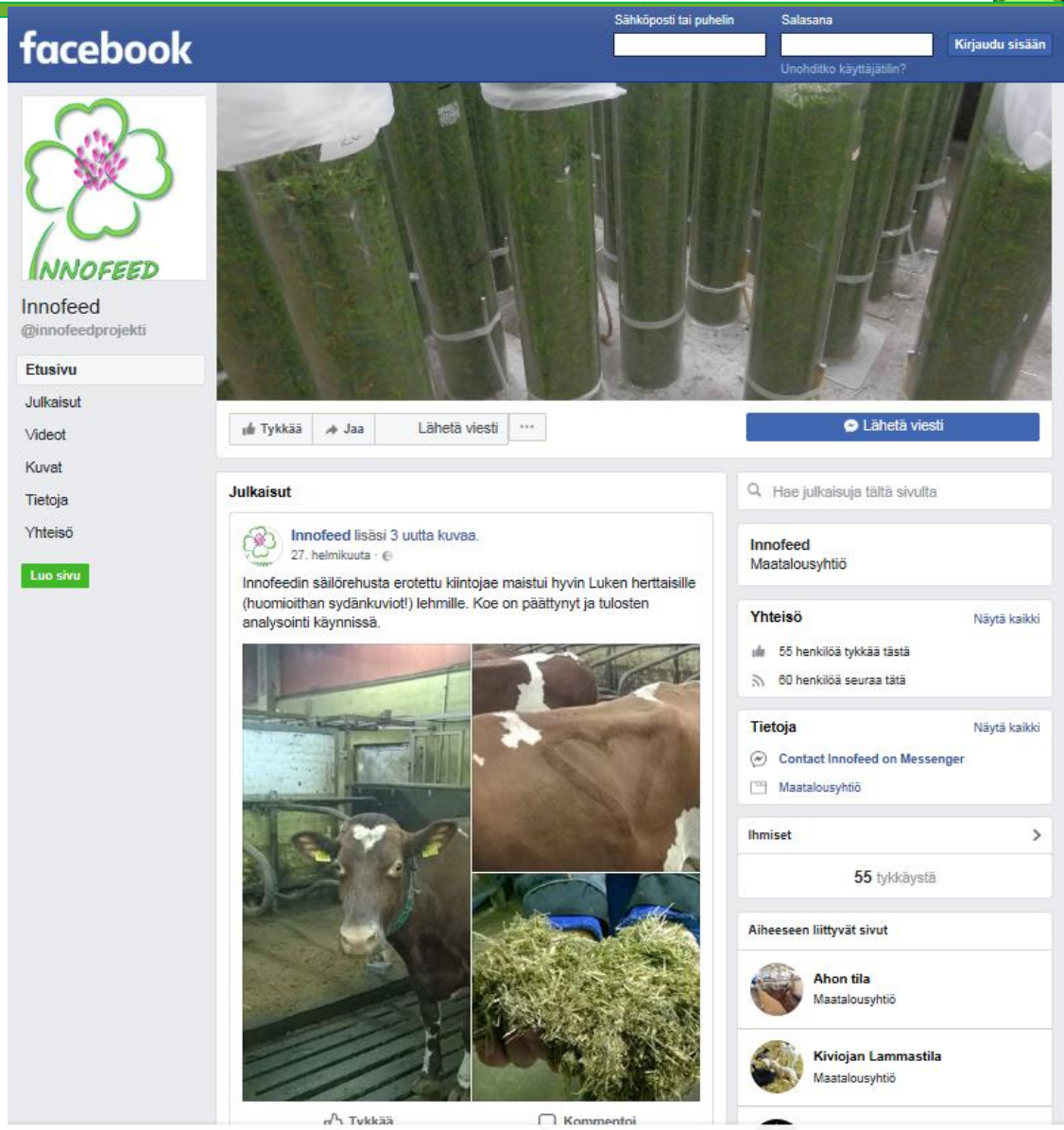
  https://www.ibcfinland.fi/projects/innofeed/

- **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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