NATURAL RESOURCES
INSTITUTE FINLAND

Grass for biorefinery: effects of pretreatments and additives on liquid yield and composition

Nisola Ayanfe

Research scientist/Doctoral researcher

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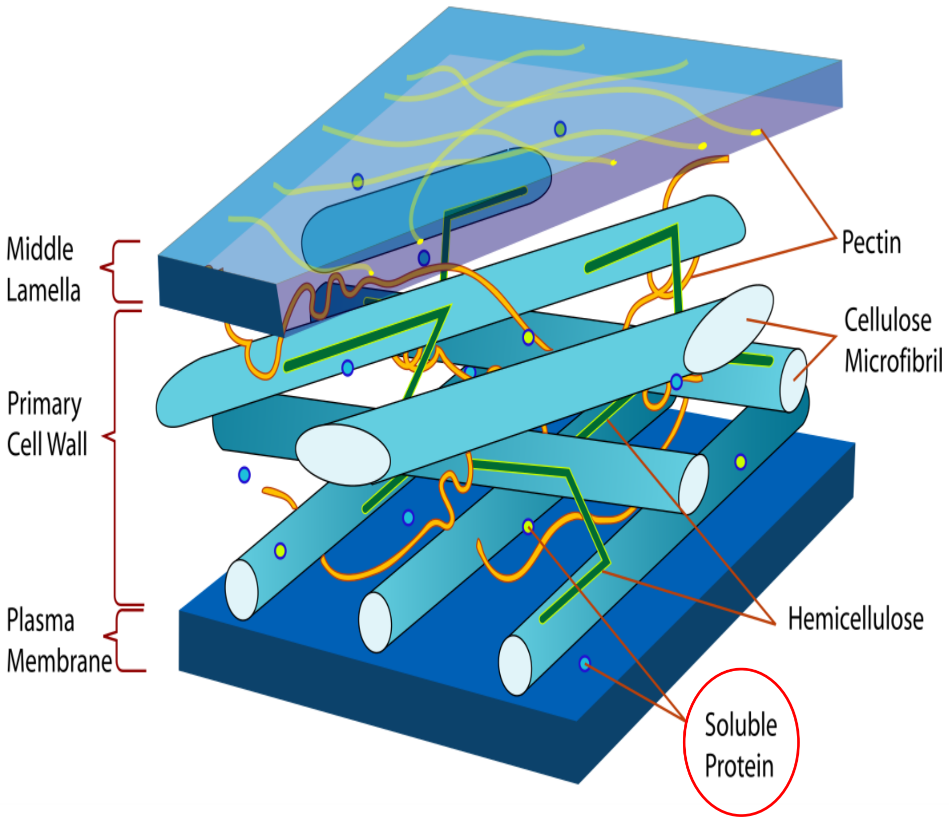
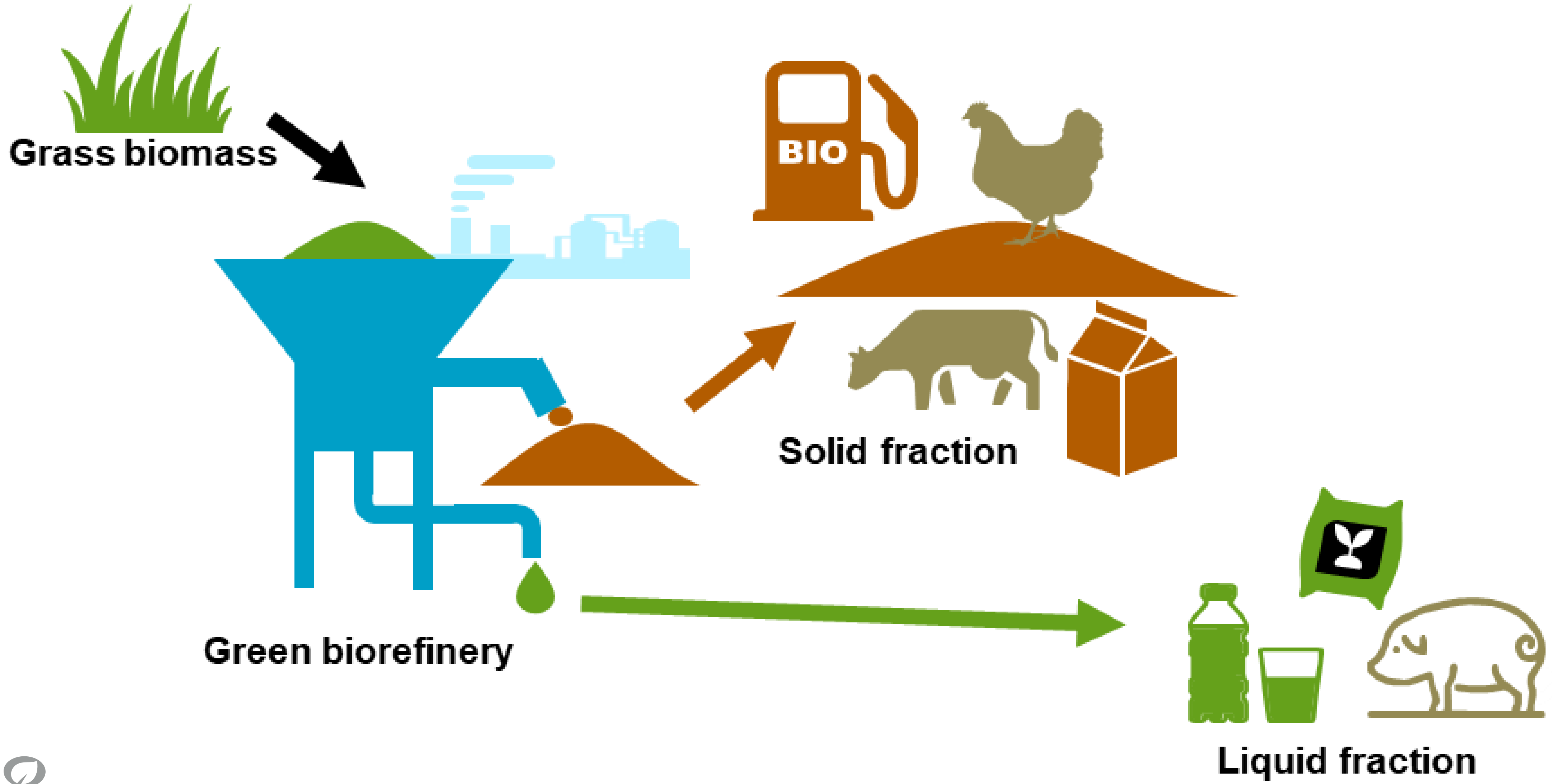
Relevance

- Grass occupies about 69% of world's agricultural area (Dengler et al., 2022)
- Valuable, nutritious and provides ecosystem benefits;
    - carbon sequestration
    - improved soil structure
    - improved biodiversity.
    - reduced erosion
- Humid climatic conditions of temperate regions favour grass production
- Prospect for alternative protein sources and other end products through green biorefinery (Jørgensen et al., 2022)



https://en.wikipedia.org/wiki/Xylan

The Green biorefinery concept



Challenges

- Highly perishable (fresh grass, biorefinery fractions).
- Poor hygienic quality.
- Availability is seasonal.

Solutions (Preservation/Pretreatment)?

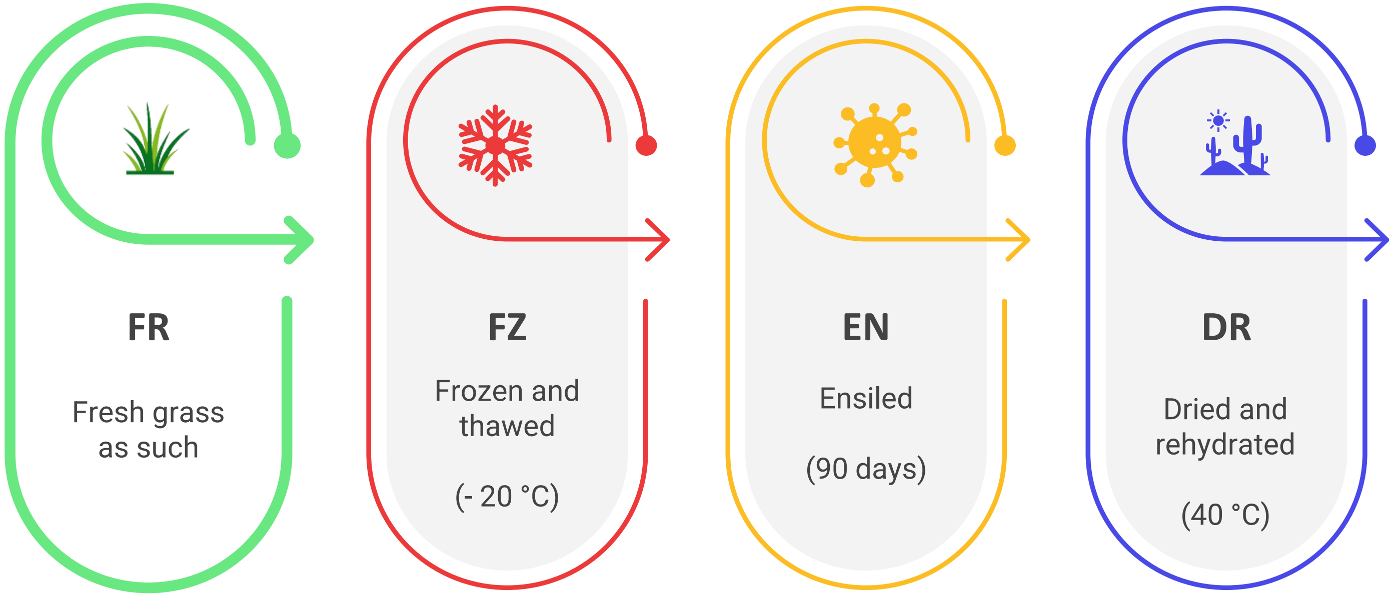
- Ensiling
- Freezing
- Drying and rehydrating

➢ Organic acid application

How?

- Second cut grass
  - Timothy *(Phleum pratense)* + Meadow fescue *(Festuca pratensis)*


Photos: ©Luke / M. Rinne



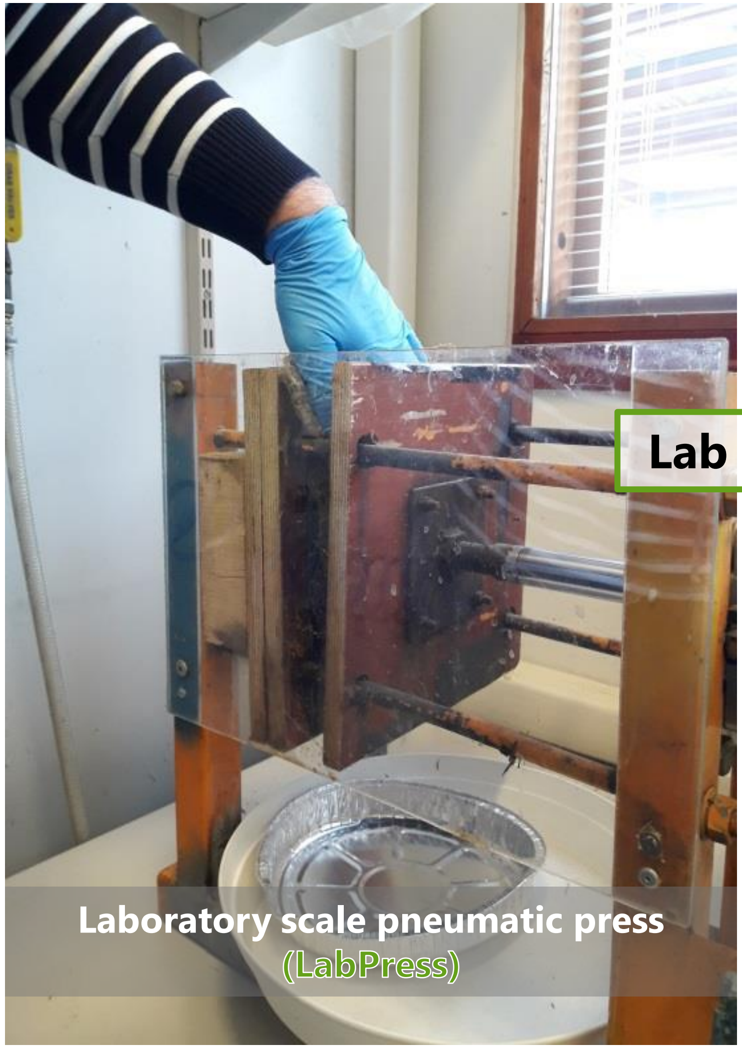
Biomass types

Control without additive
FPA: Formic and propionic acid – 5 l/t

Control: without additive

Separation techniques

Lab scale



Laboratory scale pneumatic press (LabPress)

Photo: ©Luke / M. Franco

Laboratory scale twin screw press (LabScrew)

Photo: ©Luke / T. Stefański

Farm scale

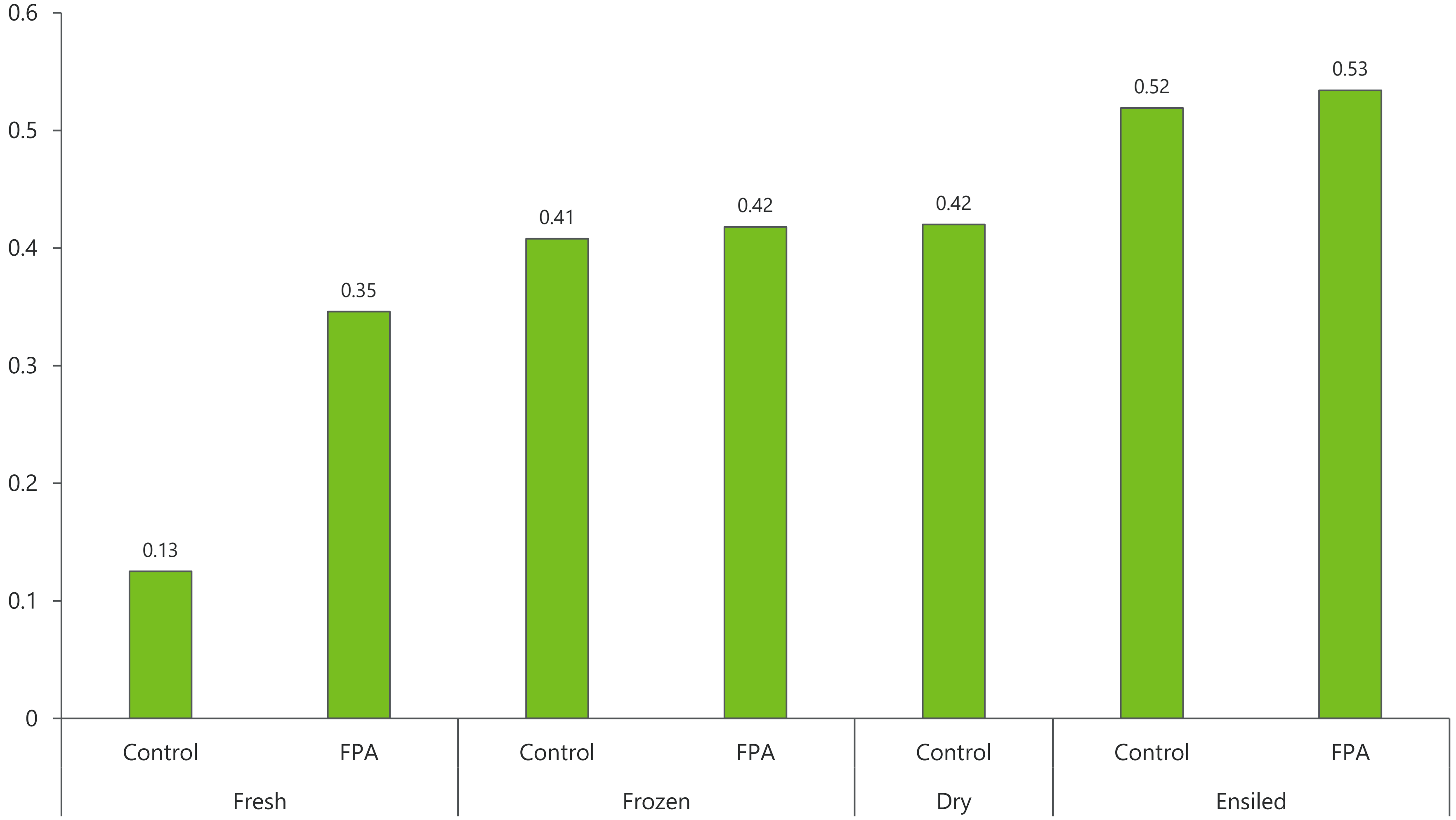
Farm scale single screw press (PilotScrew)

Photo: ©Luke / M. Rinne

Chemical composition of fresh and ensiled biomass

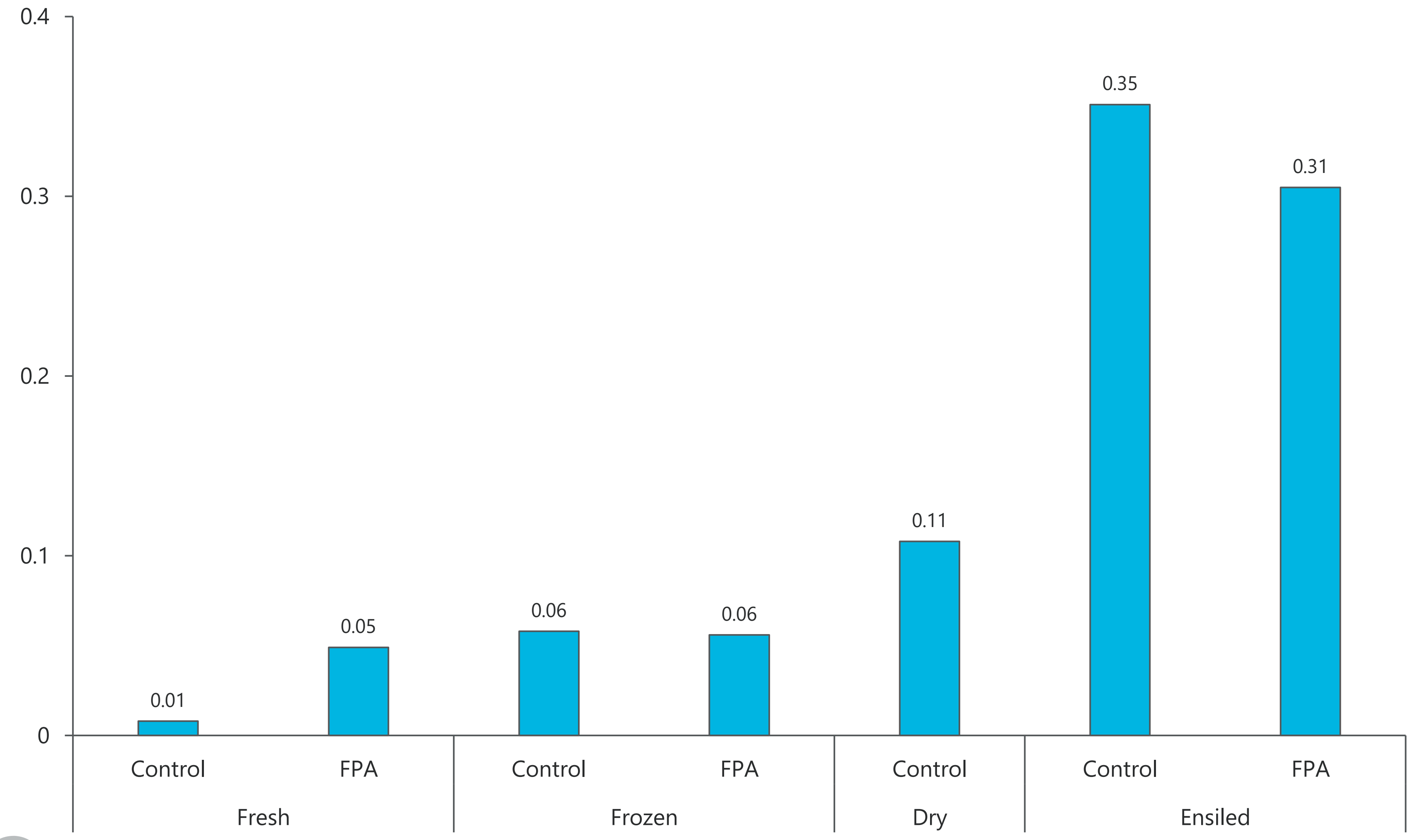
Grass treatment	Fresh	Ensiled	
Use of additive	**Control**	**Control**	**FPA**
Dry matter (DM), $g\ kg^{-1}$	218	208	208
Crude protein, $g\ kg^{-1}$ DM	123	122	123
pH	6.14	3.87	3.96
Buffering capacity, g lactic acid 100 g^{-1} DM	2.97		
Ammonia N, $g\ kg^{-1}$ N		66.2	31.8
Soluble N, $g\ kg^{-1}$ N	232	588	449
In DM, g kg-1			
Water soluble carbohydrates	125	38	106
Lactic acid		96	57
Acetic acid		26.2	17.5
Proponic acid		0.33	0.05
Butyric acid		0.05	0.05

Liquid yield (g/g) using **LabPress**



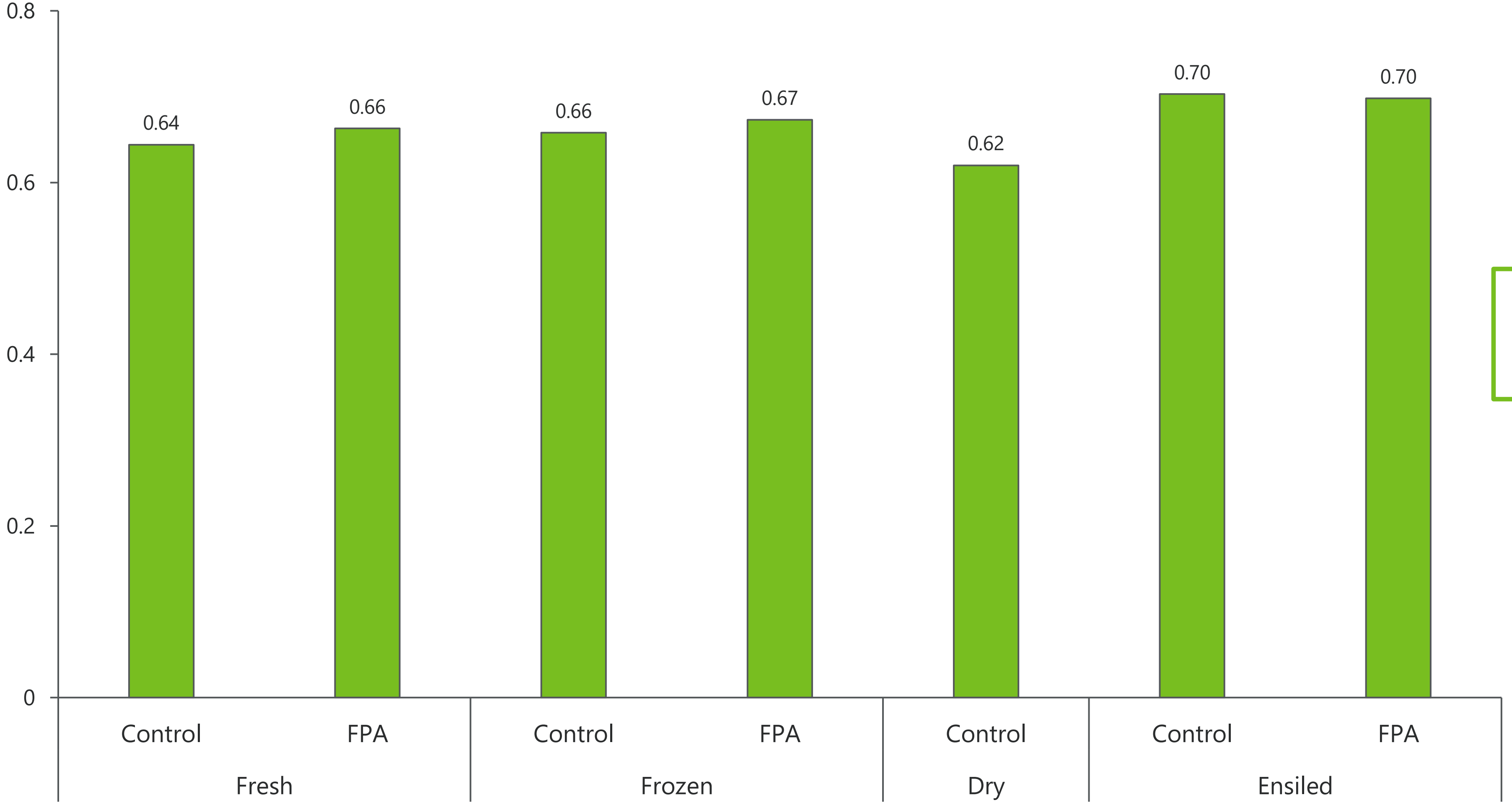
Biomass type < 0.001
FPA < 0.005
Biomass type × FPA < 0.001

CP retained in liquid (g/g) using LabPress



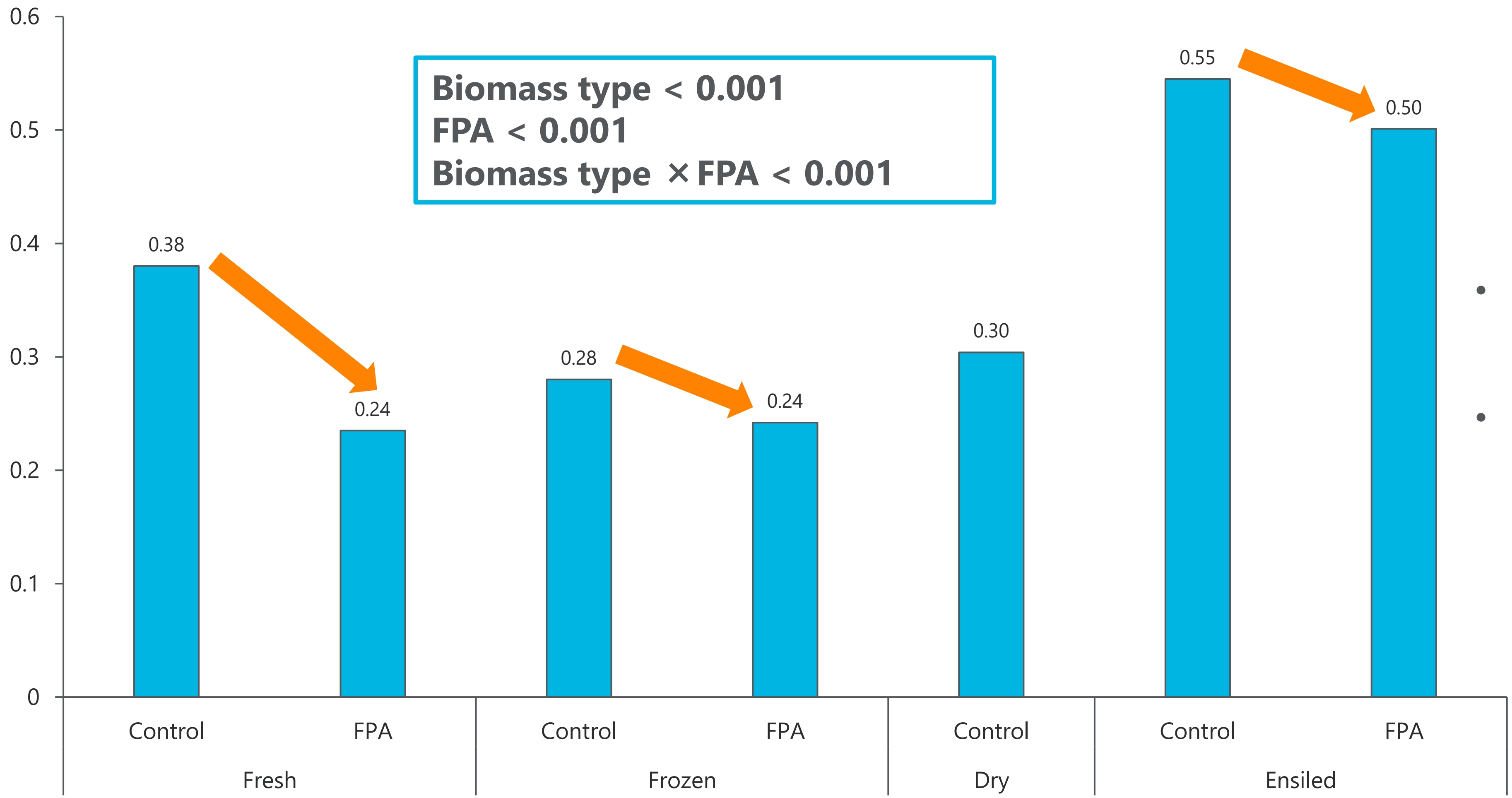
Biomass type < 0.001
FPA < 0.828
Biomass type × FPA < 0.001

Liquid yield (g/g) using **LabScrew**



Biomass type < 0.001
FPA < 0.045
Biomass type × FPA < 0.001

CP retained in liquid (g/g) using LabScrew



- True protein preserved in biomass.
- Low Soluble N concentration in FPA-treated silage.

Summary

- Organic acid-based additive positively influenced chemical composition of the ensiled biomass.
- All pretreatments increased liquid yield through cell rupture and resulted in improved protein extraction compared to fresh grass.
- The effect of pretreatment was more pronounced in the press with lower efficiency.
- Organic acid-based additive increased liquid yield but decreased protein solubility.

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The effects of grass biomass preservation methods, organic acid treatment and press type on the separation efficiency in the green biorefinery

Nisola Ayanfe [*], Marcia Franco, Tomasz Stefański, Nora Pap, Marketta Rinne

Natural Resources Institute Finland (Luke), FI-31600 Jokioinen, Finland

A R T I C L E I N F O

Keywords:
Pretreatment
Press juice
Biomass conversion
Extraction
Additive
Fractionation
Screw press

A B S T R A C T

Processing green biomass into novel products provides opportunities to improve the sustainability of the bio-economy. The objective of this study was to evaluate the effects of biomass types (fresh, frozen-and-thawed, dried-and-rehydrated and ensiled grass) as well as formic and propionic acid-based additive on the efficiency of liquid-solid separation and crude protein (CP) yield. Three different pressing methods for liquid-solid separation were used. All preservation methods improved biorefinery efficiency compared to fresh grass, and the effect of additive was more profound on the fresh biomass than other materials. However, due to lower CP concentration in the liquid, presumably caused by lower nitrogen solubility, the amount of CP retained in the liquid was not improved in response to the additive treatment. The type of processing technology plays a key role in the extraction of relevant compounds from biomass. With less efficient separation methods, the effects of pretreatments were more pronounced.

XIX International Silage Conference 2023

8 – 12 August, 2023 – Beijing, China

Suomen Nurmiyhdistys ry

Participants and Program

- 270 participants from 16 countries
- 4000 online attendees
- Presentation on major subjects
    - Advances in silage research
    - Silage utilization and animal production
    - Silage technology and management
    - Biochemistry and microbiology

Grass for biorefinery – Effects of pretreatments and additives on liquid yield and composition

Nisola Ayanfe, **Tomasz Stefański, Marcia Franco, Marketta Rinne**
Natural Resources Institute Finland (Luke), FI-31600 Jokioinen, Finland. nisola.ayanfe@luke.fi

Introduction

- Use of grass is limited to ruminants due to capture of **soluble nutrients** in fibre matrix of plant cells.
- Concept of green biorefinery utilizes **green biomass** as raw material to generate **valuable products** and other **side streams**.

Figure 1. The Green biorefinery concept

- Pretreatment is needed to ensure **continuous availability** of biomass and **stability** of biorefinery products.

Aims

- To compare liquid and protein yields from ensiling, drying and rehydrating as well as freezing and thawing to the use of fresh grass.
- To evaluate the effect of organic acid-based additive on separation efficiency.

Materials and Methods

- First regrowth grass harvested on 9th September 2021.
- Mixture of Timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*) sward.
- Treatments: 4 biomass types, formic/propionic acid (FPA) application, 3 replicates.

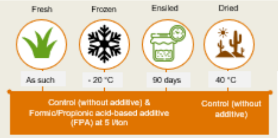

Figure 2. Biomass types produced from pretreatment of grass and organic acid-based additive (FPA)

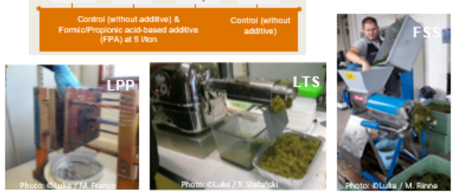

Figure 3. Biomass types pressed using a) Laboratory scale pneumatic press (LPP), b) Laboratory scale twin screw press (LTS), c) Farm scale single screw press (FSS)

Results and Discussion

- Ensiled biomass was well fermented with pH < 4 and additive treatment improved fermentation quality.
- Ensiling resulted in highest liquid yield and crude protein recovery in the liquid.
- Pretreatment effect was more pronounced when a less efficient press (LPP) was used.

Table 1. Chemical composition of fresh and ensiled grass biomass

Biomass characteristics	Fresh	Ensiled	
		Control	FPA
Dry matter, g/kg	218	208	208
In dry matter, g/kg			
Crude protein	123	122	123
Water soluble carbohydrates	125	38	106

Figure 4. Effects of grass biomass types (Fresh; Frozen; Dried and rehydrated (Dry); ensiled) and formic/propionic acid-based additive (FPA) on liquid yield and crude protein (CP) retained in liquid using lab-scale pneumatic press (LPP) and lab-scale twin screw press (LTS)

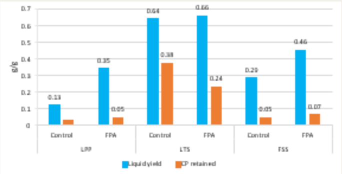

Figure 5. Effects of press types (LPP, LTS and FSS) and additive treatment (Control vs FPA) on liquid yield and crude protein (CP) retained in liquid as a proportion of original fresh biomass

All pretreatments (freezing, drying and ensiling) improved protein extraction compared to fresh grass. Organic acid-based additive increased liquid yield but decreased protein solubility.

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Nisola Ayanfe
nisola.ayanfe@luke.fi
+358 504734178
Nisola Ayanfe