Microbial Inoculant Effects on Warm-Season Perennial Grass Silage

XX International Silage Conference

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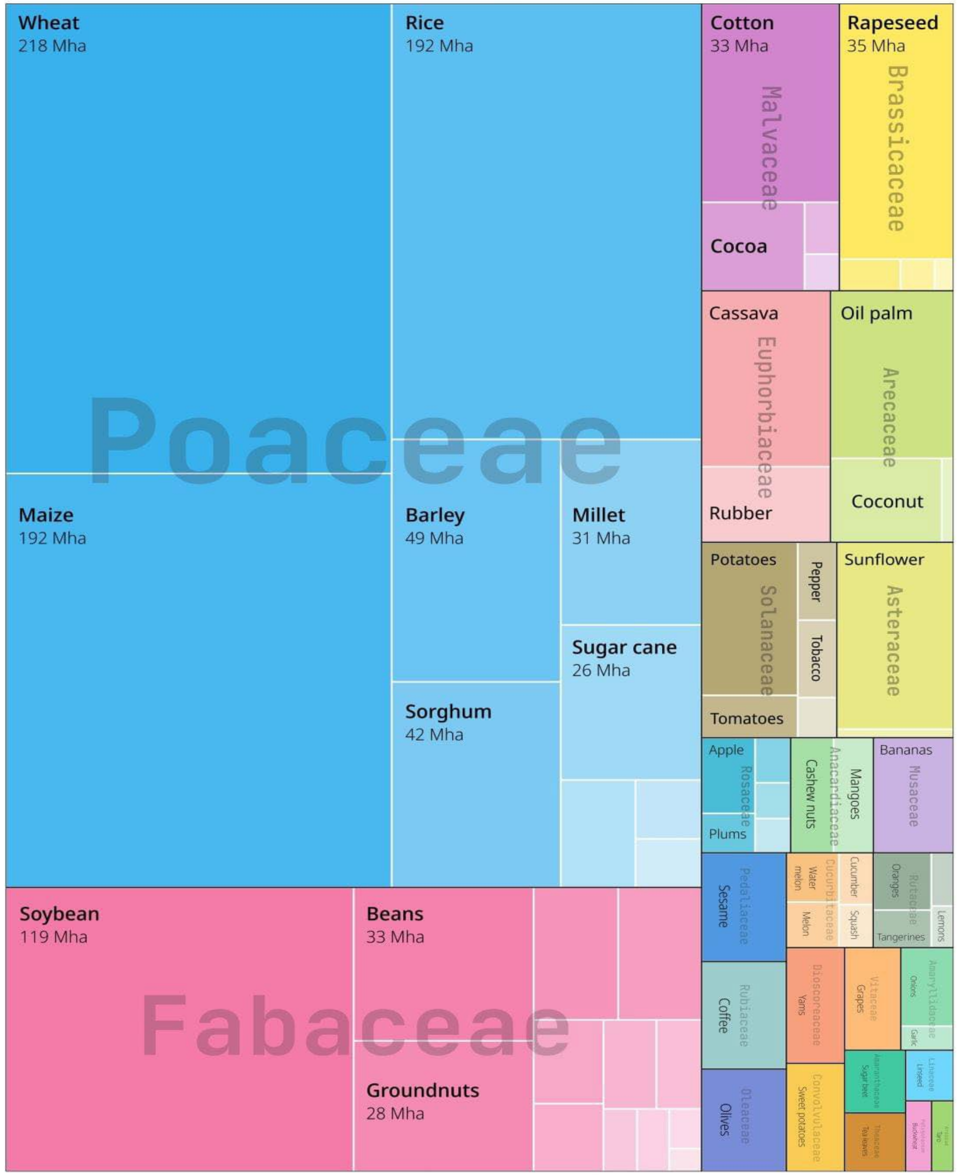
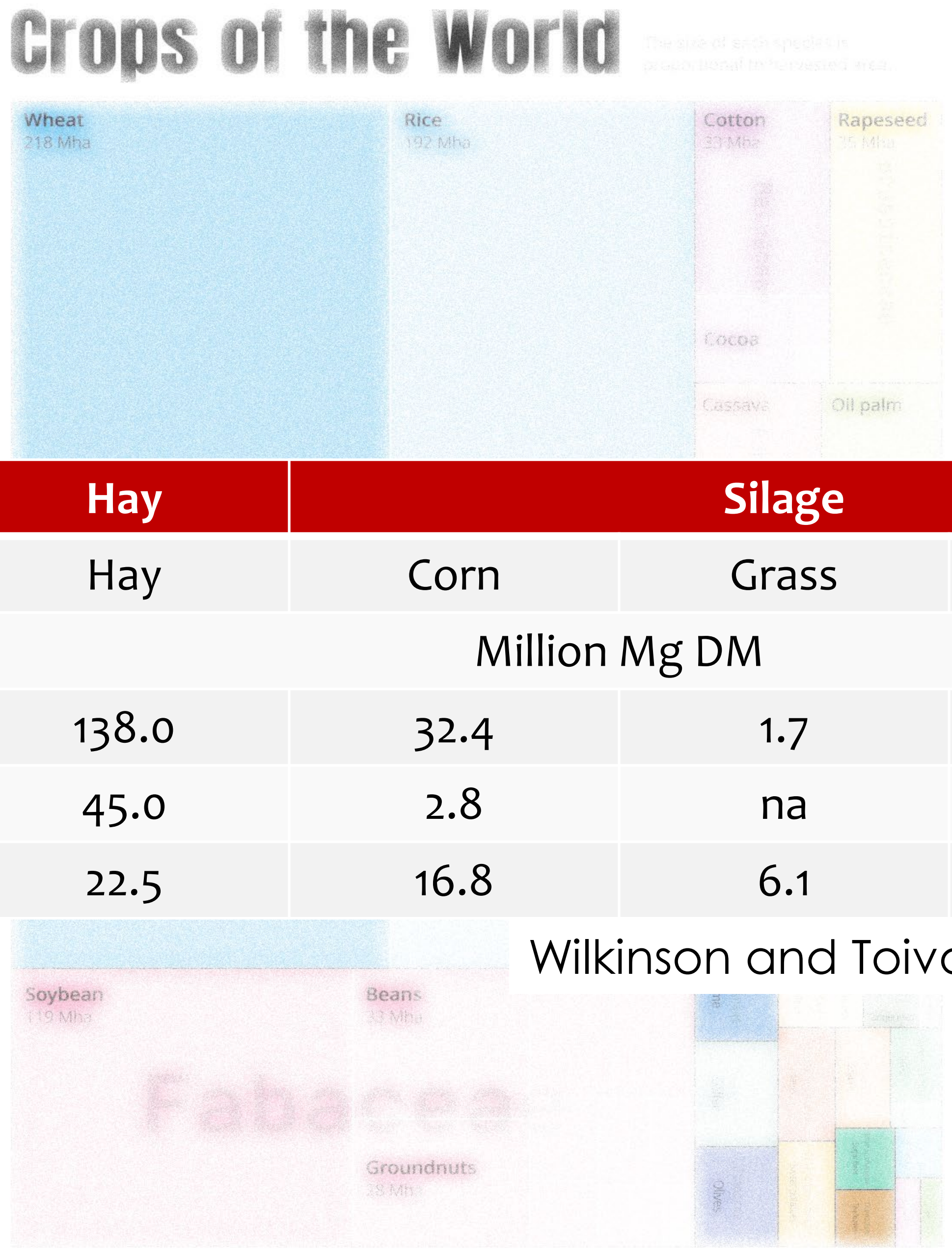
Crops of the World

The size of each species is proportional to harvested area.

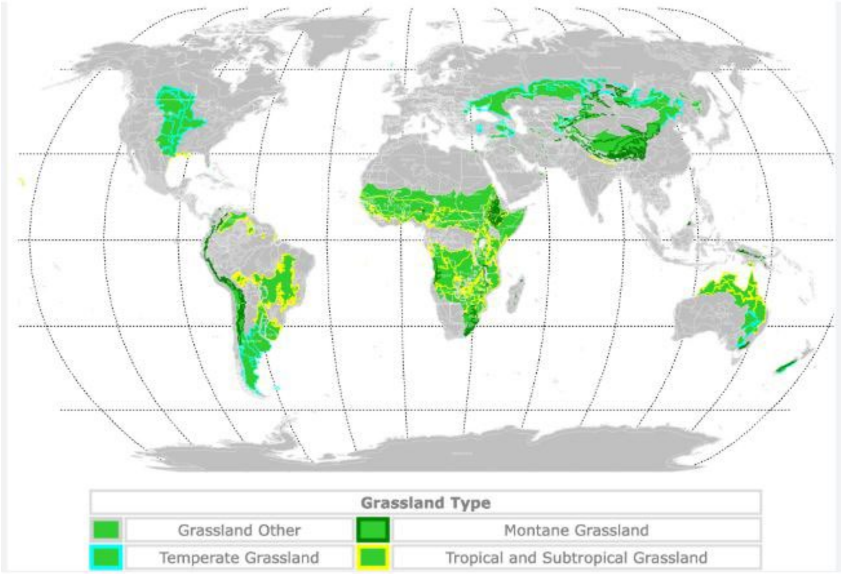


Data FAOStats (average from 2011 to 2021) | Plot Benjamin Nowak



Country	Hay	Silage		
	Hay	Corn	Grass	Other
	Million Mg DM			
USA	138.0	32.4	1.7	9.0
Canada	45.0	2.8	na	4.8
France	22.5	16.8	6.1	5.3

Wilkinson and Toivonen (2003)



- Grasslands cover approximately 40% of the world's terrestrial surface (Moore et al., 2020)
    - Cropland forage
    - Grazingland
        - Pastureland
        - Rangeland

Grass Silage Fermentation Characteristics

- In general, grasses have undesirable characteristics to be preserved as silage:

- Reduced DM concentration

- Reduced water-soluble carbohydrates concentration

- Relatively greater buffering capacity than corn and sorghum

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Grass Silage Fermentation Characteristics

	C3 Grass	C4 Grass	Temperate Legumes
		% DM	
Soluble Sugars	3-6	1-5	2-5
Starch	0-2	1-5	1-11
Fructan	3-10	-	-
		meq/kg DM	
Buffering Capacity	265 (Timothy)	388 (Kikuyugrass)	472 (Alfalfa)

Adapted from Muck et al. (2020)

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Popular inoculants used in silage

Genus of LAB	Strains of species LAB	Characteristics	References
Lactobacillus	*L. plantarum*	Dynamic increase of population in silage, antibacterial and antifungal activity, decontamination of mycotoxins	Luz et al. (2018), Guo et al. (2018) and Zielińska et al. (2014)
	L. casei	Probiotic bacteria, antibacterial and antifungal activity, decontamination of mycotoxins	Vinderola and Ritieni (2015) and Luz et al. (2018)
	L. rhamnosus	Probiotic bacteria, antibacterial and antifungal activity, decontamination of mycotoxins	Vinderola and Ritieni (2015) and Luz et al. (2018)
	L. buchneri	Synthesis and/or metabolize 1,2-propanediol, improvement of aerobic stability, increasing the biogas yield	Zhang et al. (2009), Herrmann et al. (2015), Comino et al. (2014) and Zielińska et al. (2016)
	L. diolivorans	Metabolize of 1,2-propanediol to propionic acid, improving: aerobic stability of silage and biogas yield	Krooneman et al. (2002), Charley and Kung (2005) and Zielińska et al. (2017)
Pediococcus	*P. pentosaceus* *P. acidilactici*	Probiotic bacteria, pediocin producers, increasing the preservation of dry matter and/or protein in silage, decontamination of mycotoxins	Dellaglio and Felis (2005) and Porto et al. (2017)
Enterococcus	*E. faecium*	Dynamic increase of bacterial population, decreasing pH in silage, probiotic activity	Dellaglio and Felis (2005) and Li and Nishino (2011)

Weinberg and Muck (1996)

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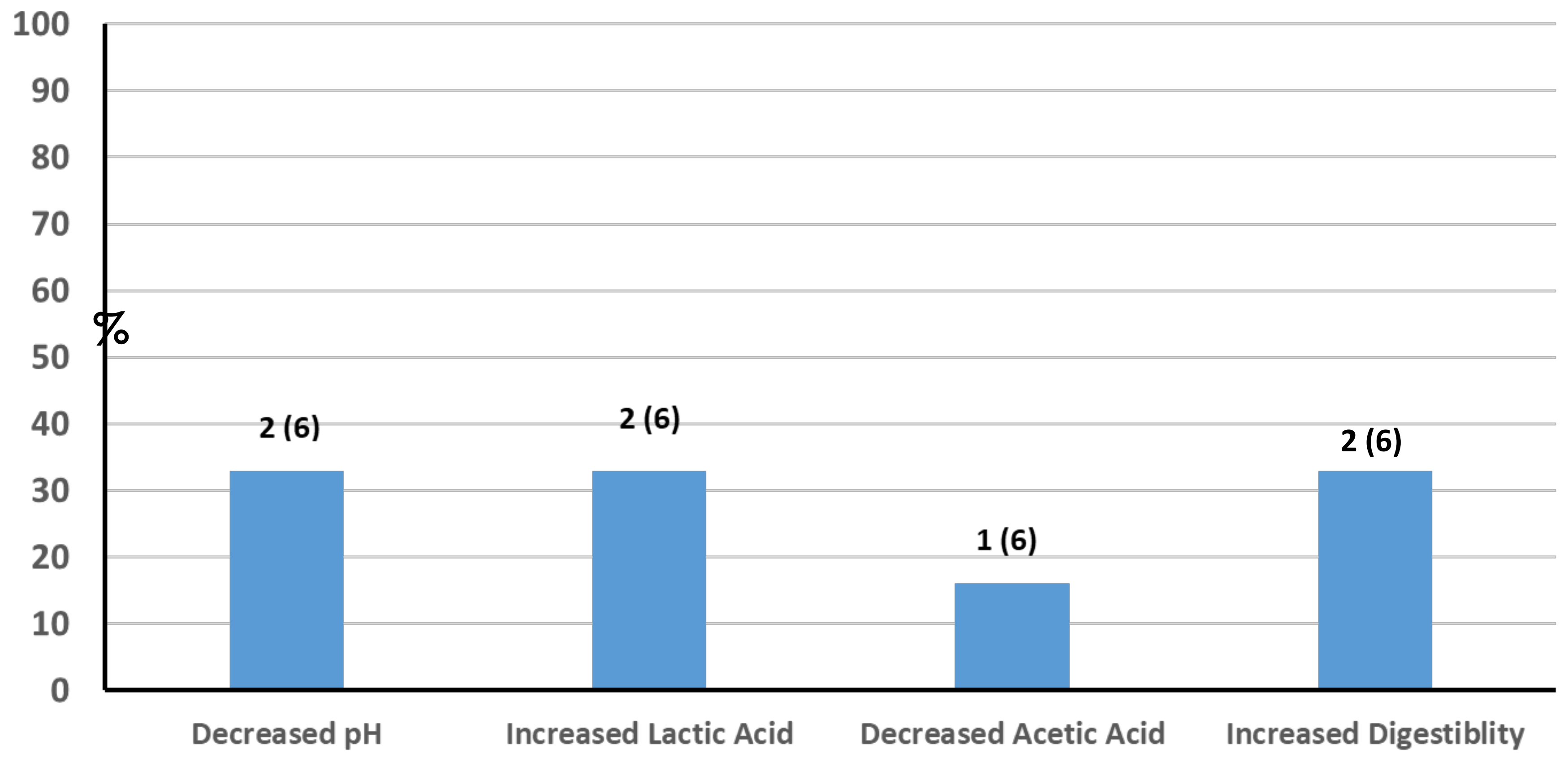
Microbial Inoculants – Grass Silage

- Failure to dominate the fermentation by:
  - Epiphytic LAB population
  - The inoculant may have dominated the fermentation in treated silage, but the control silage had adequate fermentation
  - The inoculants were infected by phage
  - Technical problems such as the LAB not being viable at the time of application
  - **Forage chemical characteristics were inadequate for proper fermentation**

Microbial Inoculant effects – C4 perennial grasses



C4 perennial grasses

Item	Inoculant									
	Control	B500	BPII	ESA	F20	F600	HQ	VS-3	*P* value	SE
pH	4.6^{b}	4.95^{ab}	4.9^{a}	4.8^{ab}	4.8^{ab}	4.91^{ab}	4.7^{ab}	4.6^{b}	0.007	0.1
Lactic acid, % DM	2.23^{a}	0.60^{ab}	0.91^{ab}	1.64^{ab}	1.59^{ab}	0.47^{b}	1.64^{ab}	1.97^{a}	0.01	0.68
Acetic acid, % DM	2.45^{ab}	3.32^{a}	2.35^{ab}	2.46^{ab}	2.41^{ab}	1.84^{ab}	2.03^{ab}	0.32^{b}	0.04	0.32
Propionic acid, % DM	0.35	0.39	0.29	0.40	0.35	0.57	0.31	0.27	0.40	0.15
Butyric acid, % DM	3.24	3.90	3.19	4.78	4.11	4.73	4.22	3.88	0.64	1.1
Isobutyric acid, % DM	0.15	0.17	0.20	0.25	0.11	0.11	0.14	0.09	0.28	0.3
Ammonia, % CP	21.2	28.0	29.6	26.1	18.6	20.6	21.6	19.8	0.09	6.1

	Forage Pre-Ensiling
DM (%)	25
NDF (%)	69
WSC (%)	5.2
IVTD (%)	52

Gouvea et al. (2020)

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C4 perennial grasses

	Forage Species		
	'Camello' Brachiariagrass	'Spain' Guineagrass	'Jiggs' Bermudagrass
DM (%)	24b	26a	24b
pH	4.1b	4.3a	4.0b
Latic Acid (% DM)	5.9a	4.3c	4.7b
Acetic Acid (% DM)	1.9a	2.3a	1.1b
Butyric Acid (% DM)	0.2c	0.8b	1.6a
Ammonia (% N)	20b	22ab	23a

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C4 perennial grasses – Limpograss (*Hemarthria altissima*)

C4 grasses – Limpograss (*Hemarthria altissima*)

Response variable	Treatment: Control	Treatment: Inoculant	SE	*P* value
pH	4.2	4.2	0.04	0.32
Lactic acid, %	1.6	1.4	0.14	0.27
Acetic acid, %	2.0	2.5	0.12	0.01
Propionic acid, %	1.0	1.6	0.10	0.002
Butyric acid, %	0.2	0.0	0.03	0.009
Isobutyric acid, %	0.4	0.1	0.04	0.004
Total acids, %	5.0	5.6	0.24	0.05
Ammonia, % N	5.3	4.4	0.19	0.0025

SiloSolve FC inoculant
Lactobacillus buchneri LB1819
Lactococcus lactis O224
200 g/100 ton
68.1 x 10^9 CFU[1]/g

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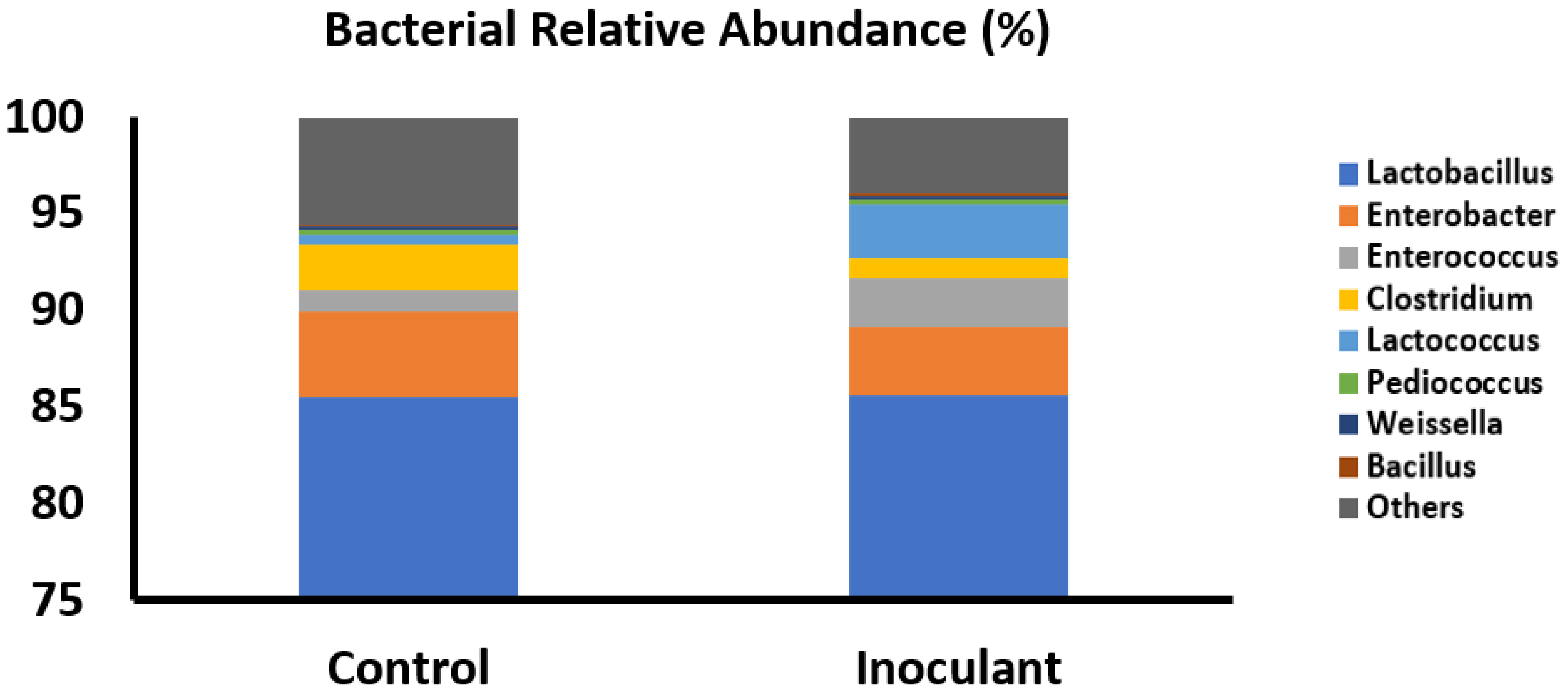
C4 grasses – Limpograss (*Hemarthria altissima*)



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Final Remarks

- Grass silage has been a feedstuff used for livestock producers for many decades
- Recent renewed interest due to development of machinery to harvest and ensile grass
- The effects of bacterial inoculants in grass silage are variable due to particular characteristics of the different grasses
- There is a need to develop a tailored recommendation of inoculants to a particular forage species and chemical composition

Thank you

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