Inoculants for improving the preservation of corn and Bermudagrass forages

Gbola Adesogan, O. Queiroz, K. Arriola, E. Muniz, J. Romero, M. Zarate, J. Hamie, J. Kivipelto

Department of Animal Sciences

IFAS

UF UNIVERSITY of FLORIDA

The Foundation for The Gator Nation

Haylage / Silage production Phases

	Before fermentation	Fermentation (front end)	Feedout (Back end)
Activity	Cutting & packing or baling	Storage of silage	Opening & feeding
Oxygen status	Present	Absent (minimal)	Present
Processes	Plant respiration	Sugar fermentation (acids produced decrease pH)	Aerobic spoilage by molds and yeasts
Problems	Nutrient losses	Shrinkage (DM losses)	Heating
Objective	Rapidly exclude oxygen from forage	Prevent oxygen entry into bunker/bale	Minimize oxygen entry
Methods	Pack well and cover or wrap promptly	Check for and seal holes	Feedout rapidly, maintain silo face

Silage bacteria battle

- Major 'germ' warfare occurs during ensiling
- GOOD GUYS vs. BAD GUYS
  Homofermenters
  Heterofermenters
  Yeasts,
  Molds,
  Clostridia

Types of Fermentation

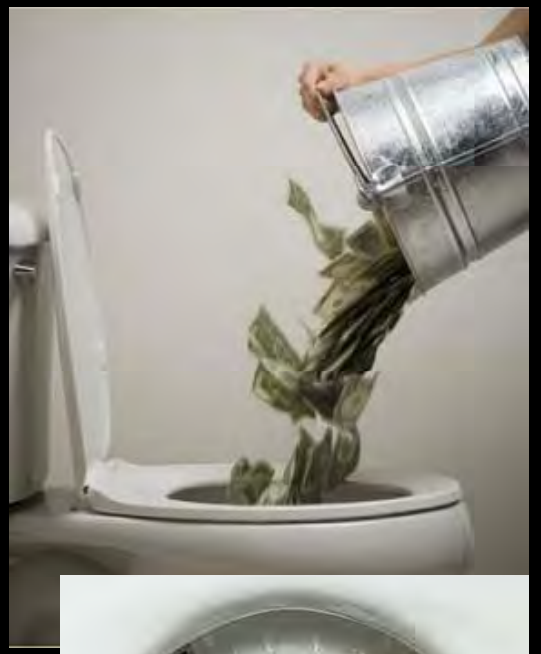
Type	Substrate *(Microbe)*	Product	Nutrient Losses
Homo-fermentative	Glucose → (*L. plantarum*)	2 x Lactic acid	Very Low
Hetero-fermentative	Glucose → (*L. buchneri*)	1 x Lactic & acetic acids, ethanol & CO_2	Low
Secondary fermentation	Lactic acid → (*Clostridia*)	Butyric acid + CO_2	High
Aerobic spoilage	Glucose, lactic acid → *(Yeasts & molds)*	Ethanol, CO_2	V. high

Poor fermentation causes

- DM, energy, and gas losses (wasted $$$$)
- Protein degradation
- Production of hazardous compounds:
  - Oxides of nitrogen
  - Foul smelling, intake depressing butyric silage
  - Toxic biogenic amines

Poor bunk life (aerobic spoilage) causes:

- Shrinkage – DM losses
- Heating by yeasts and molds
- Energy and nutrient losses
- Reduced animal performance
- Diseases (bloody gut, aspergillosis)
- Growth of pathogenic bacteria
- Mycotoxin production



USING INOCULANTS TO IMPROVE SILAGE QUALITY

Inoculants

- **What are they**

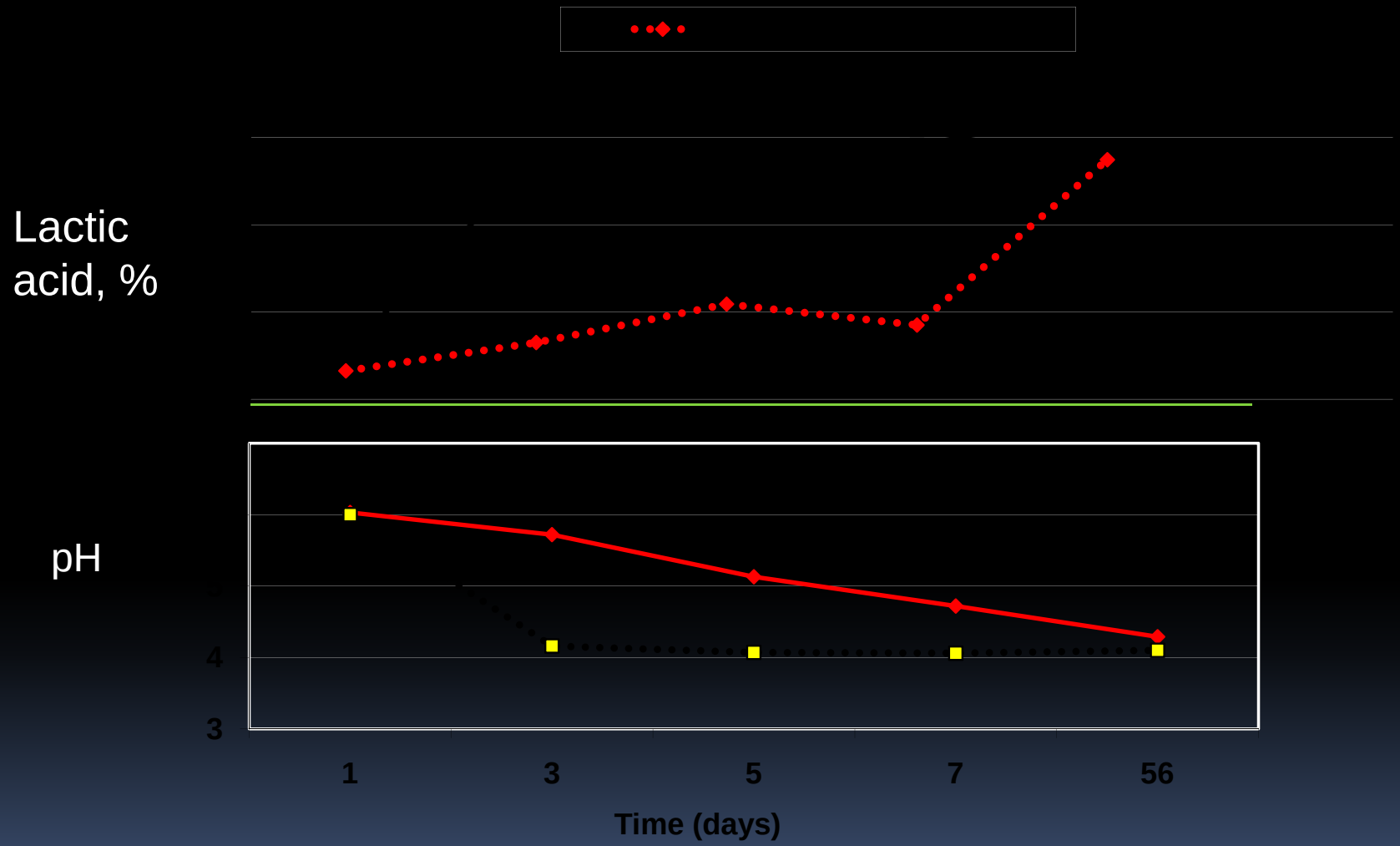
  Special bacteria added to dominate the natural plant bacteria population and improve silage quality

- **Types**
  1. **Homolactic** inoculants
  2. **Heterolactic** inoculalnts
  3. **Combo** inoculants

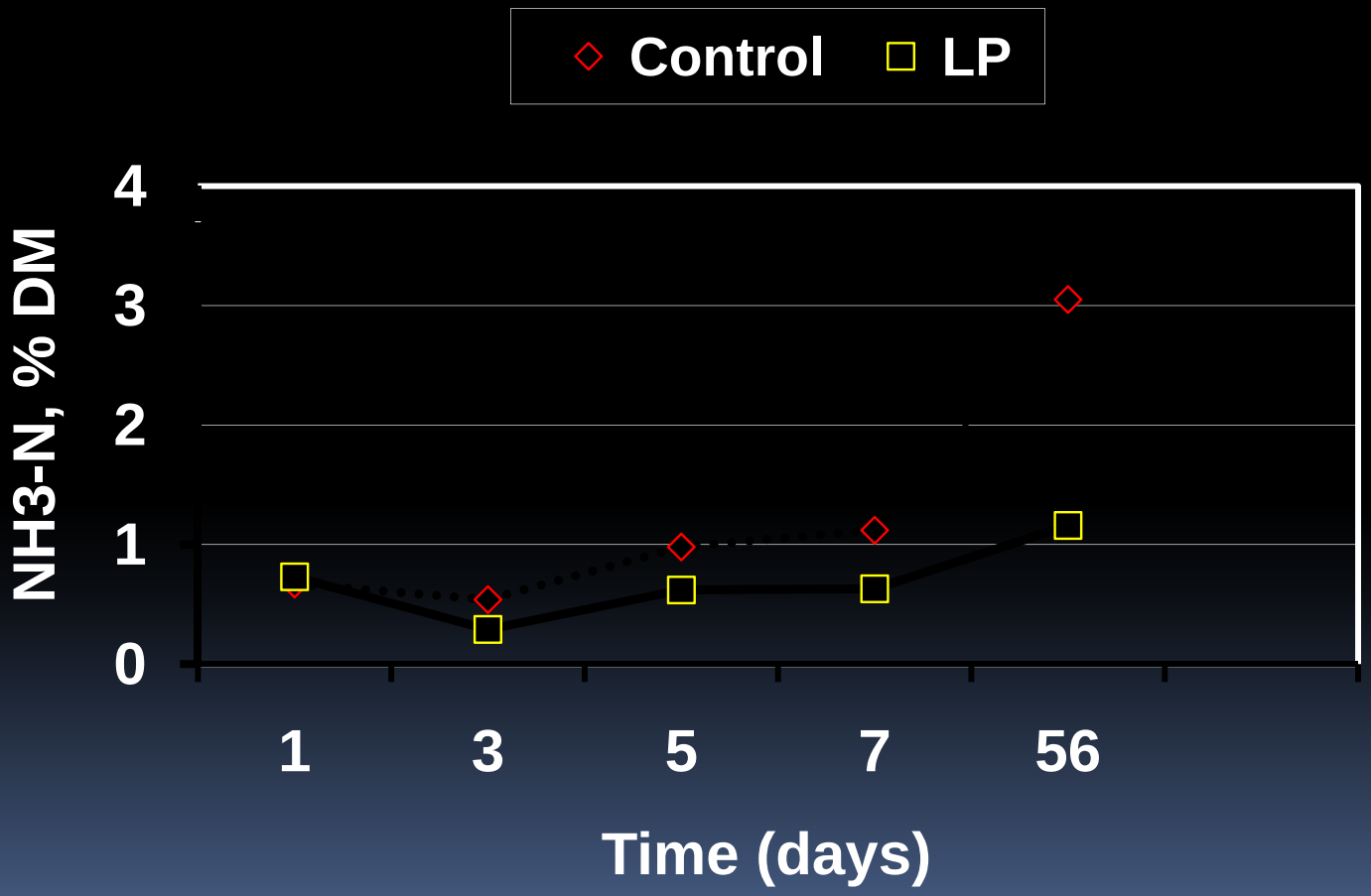
1. Homolactic inoculants

- Added to improve silage ‘fermentation’
- Typically contain *Lactobacillus plantarum or Pediococcus* bacteria
- Increase the acid production rate by fermenting sugars to lactic acid
- Rapidly reduce pH and prevent poor fermentation
- Minimize nutrient, DM and gas losses

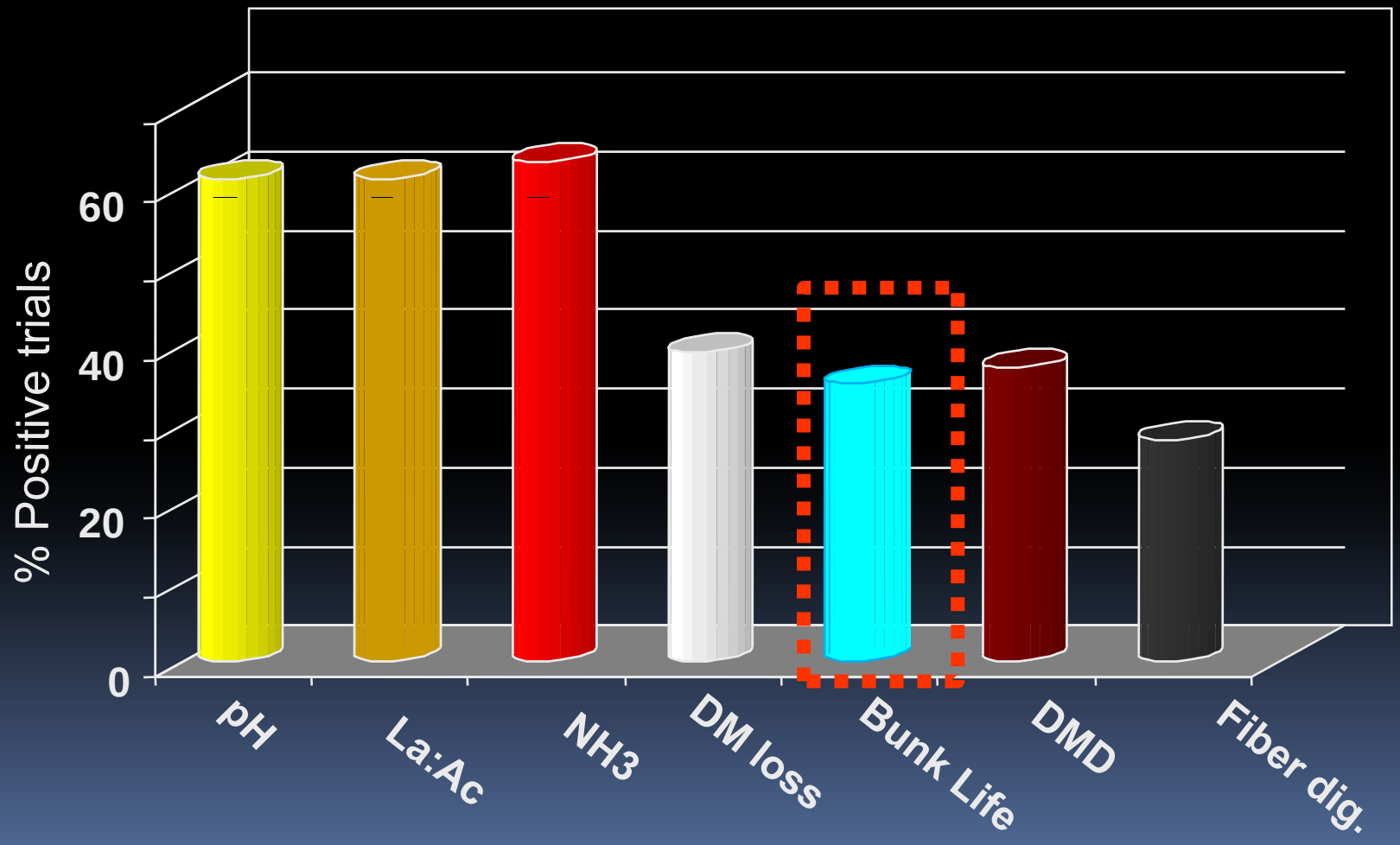
Effect of L. plantarum (LP) on alfalfa silage



Effect of L. plantarum on protein degradation



Effectiveness of homolactic inoculants

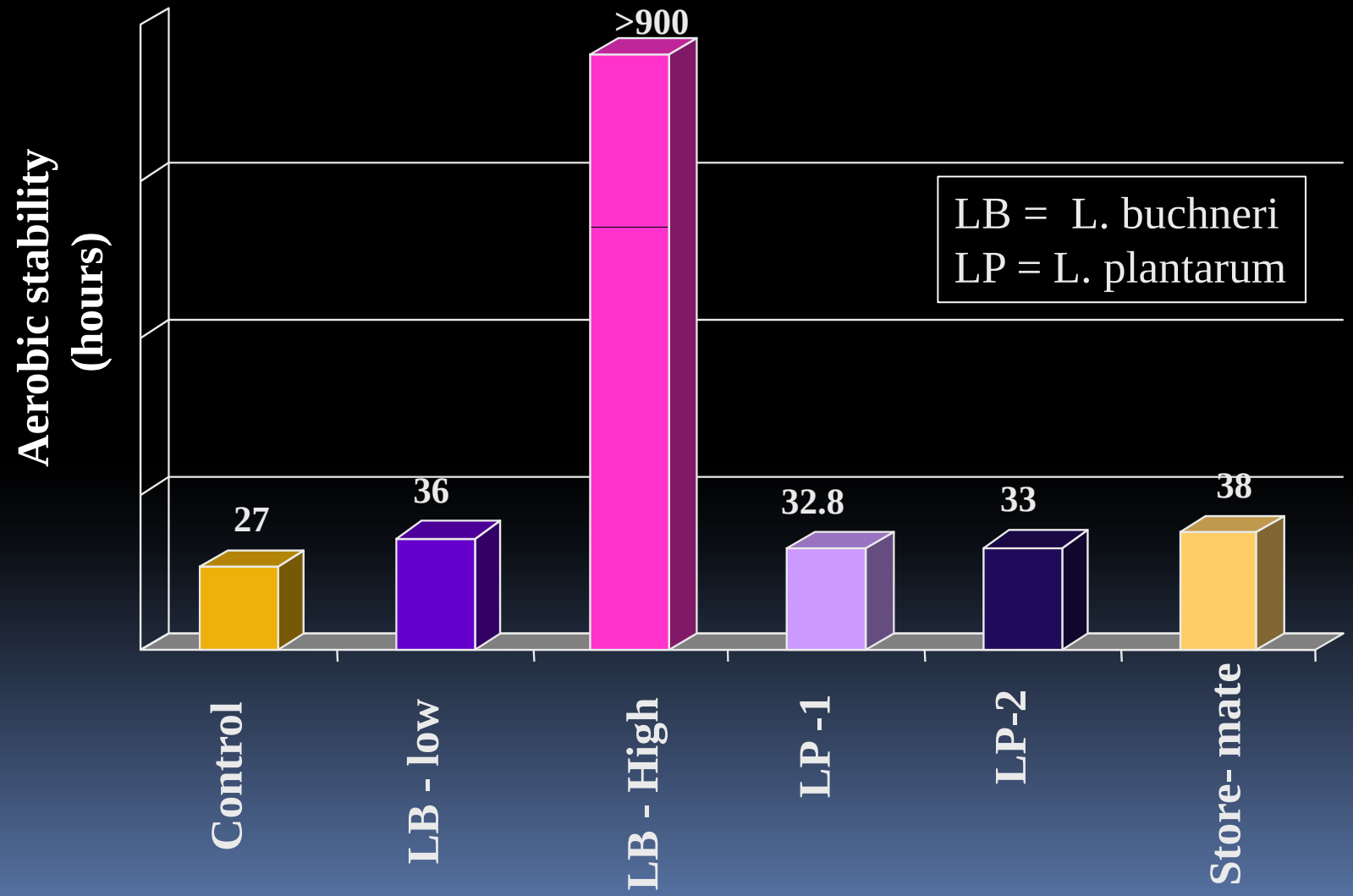


(Muck & Kung, 1997)

2. Heterolactic inoculants

- Aim to improve bunk life
- Best ones contain *Lactobacillus buchneri*
- Produce less lactic acid and more acetic acid than homofermenters
- Acetic acid kills yeasts and molds that reduce bunk life
- Hence, L. buchneri inoculants improve bunk life
- Others with Propionibacterium are less effective

Effect of different inoculants on bunk life (aerobic stability) (Ranjit & Kung, 2000)



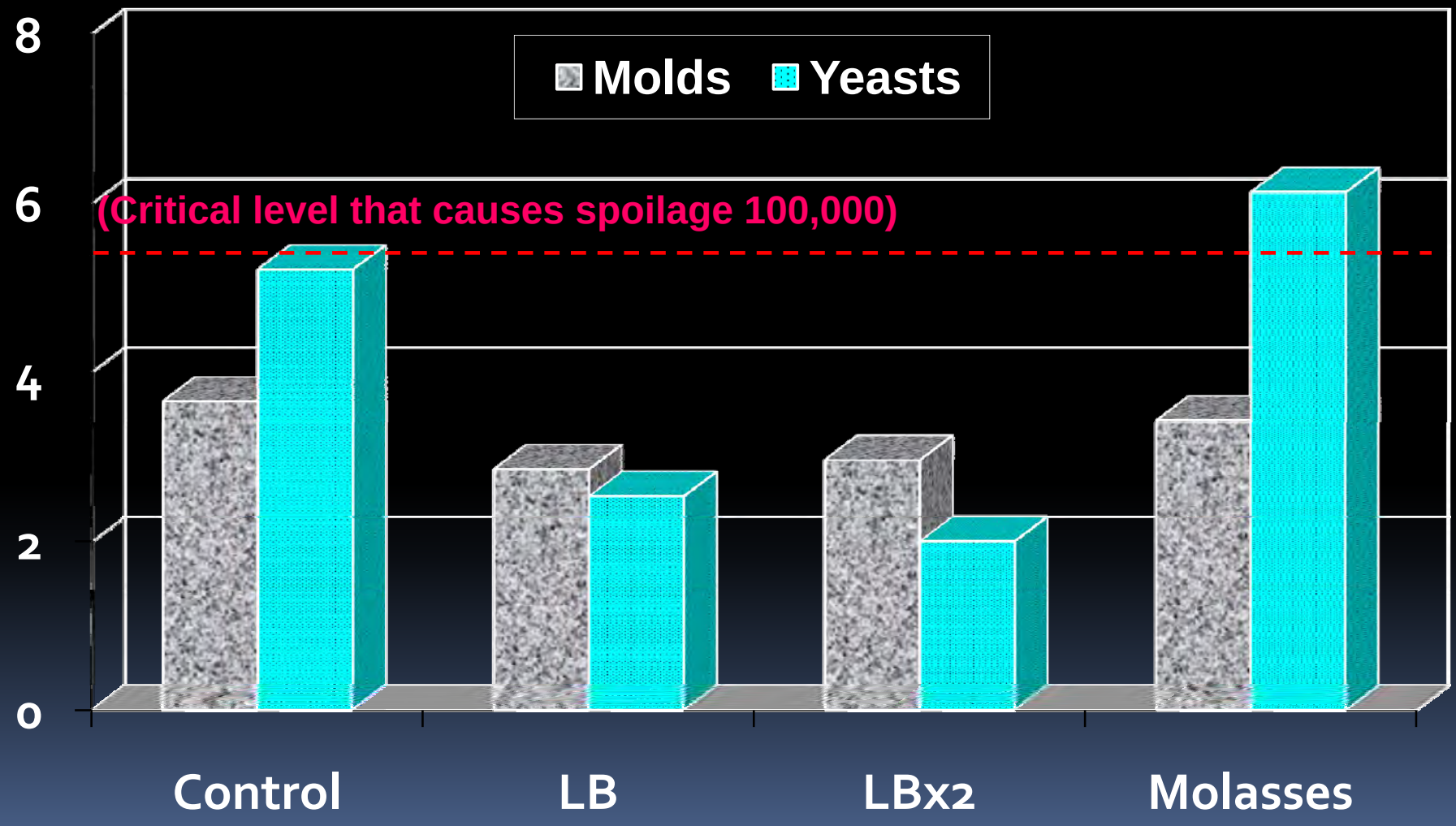
3.Combo inoculants

- Aim to improve fermentation and bunk life
- Contain both:
  - homolactic bacteria
    (e.g L. plantarum or Pediococcus pentosaceus)

    and

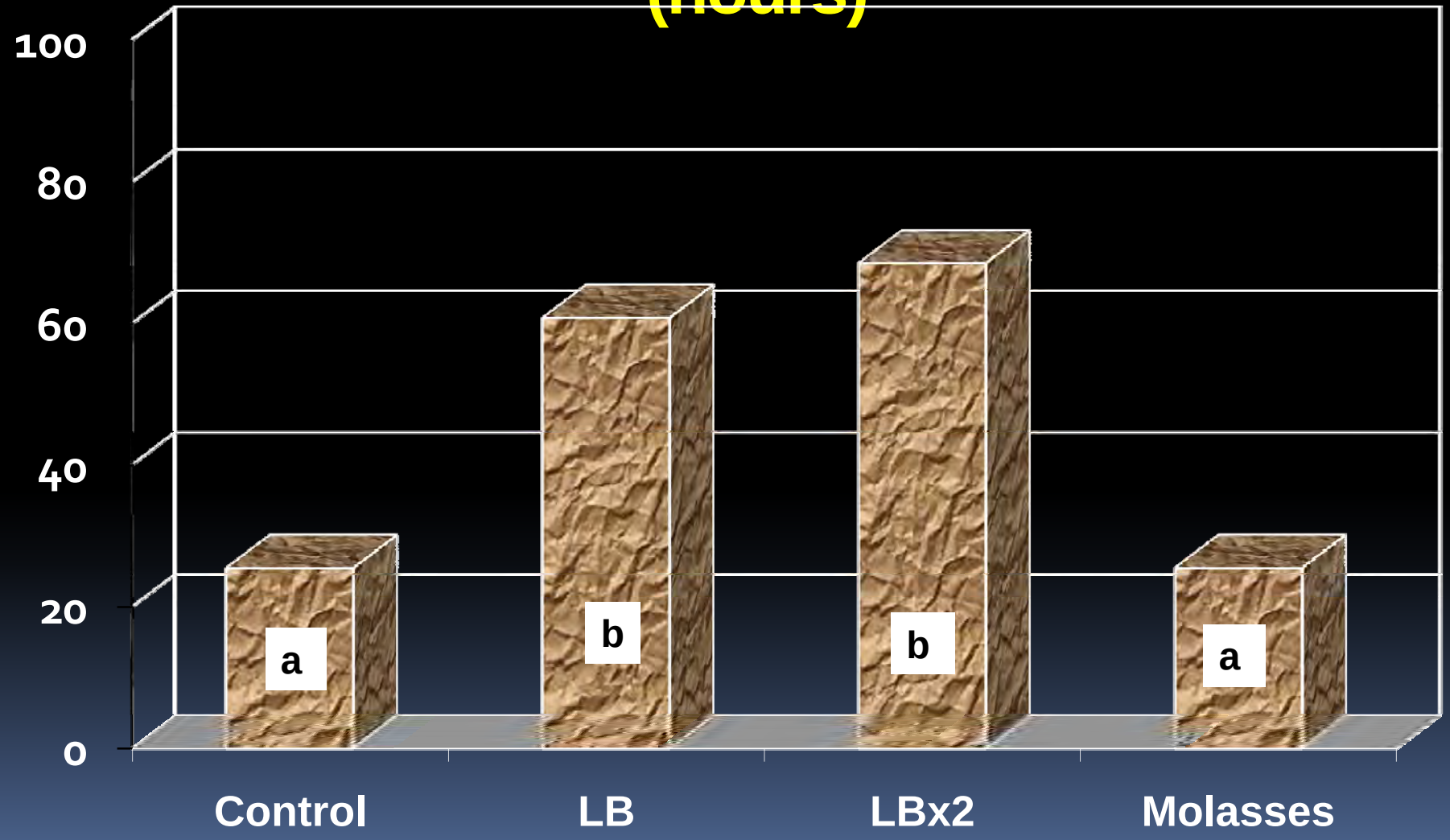
    heterolactic bacteria
    (e.g. L. buchneri)

Combo inoculant effects on spoilage organisms (Log cfu/g)



Huisden et al., 2009

Combo inoculant effects on bunk life (hours)



Huisden et al., 2009

Inoculant effects on corn silage made in Ag bags

- **Treatments**:
  - Control
  - Buchneri 500 Combo inoculant (B500)

- Four Ag bags were filled with 35 tons of silage for each treatment

- Measured quality, losses, and heating every week for 5 weeks after bags were opened

Queiroz et al., 2010

Inoculant effects on amounts of good and spoiled silage

	Control	B500	SE	Treat.	Treat. x time
Good silage					
Amount, lb DM/day	343	352	2.12	0.23	0.65
Percentage	92.2	96.6	1.08	0.004	0.71
Spoiled silage					
Amount, lb DM /day	28	12	1.53	0.002	0.49
Percentage	7.8	3.4	1.08	0.004	0.71

Queiroz et al., 2010

Inoculant effects on nutrient losses in spoiled silage

	Control	Inoculant	SE	Treat	Treat x time
CP lb/day	2.0	0.50	0.20	0.03	0.39
ADF, lb/day	5.6	1.8	0.54	0.04	0.51
NDF, lb/day	9.0	3.0	0.88	0.04	0.51
Ash, lb/day	0.3	0.07	0.03	0.03	0.30
Gross energy, kcal/day	1842	433	402	0.02	0.29

Queiroz et al., 2010

Inoculant effects on spoilage indicators

	Control	B500	SE	Treat	Treat. x time
Yeasts and molds, log cfu/g	4.62	2.59	0.65	0.07	0.07
Average ensiling temp.(ºF)	73	72	0.7	0.09	NA
Bunk life (h)	9.5	14.7	10.6	0.71	0.35
Silo face temperature (h)	97	95	1.22	3.3	0.99
Max. aerobic temp (ºF)	86	84	3.4	0.52	NA
Sum of feedout temp. (ºF)	129	122	17.2	0.89	NA

Queiroz et al., 2010

Inoculant effects on spoilage and performance of dairy cows

	CON	BPII	LB	B500
Aerobic stability, h	95.20[a]	85.13[a]	177.75[b]	77.50[a]
Spoilage losses, % DM	24.9	27.4	20.2	22.2
DMI, lb/day	43	46	44.8	43.2
Milk yield, lb/day	69.0	73.6	74.1	68.6

Arriola et al., 2011

Effect of different inoculants on bermudagrass haylage

- **Treatments**
  - Control
  - Biotal II plus (*combo with Propionibacteria*) **(BPII)**
  - Silage inoculant (*homolactic*) **(SI)**
  - Buchneri 500 (*combo with Buchneri*) **(B500)**
  - Silo King (*homolactic*) **(SK)**

- Each treatment was applied to 8, 900-lb bales

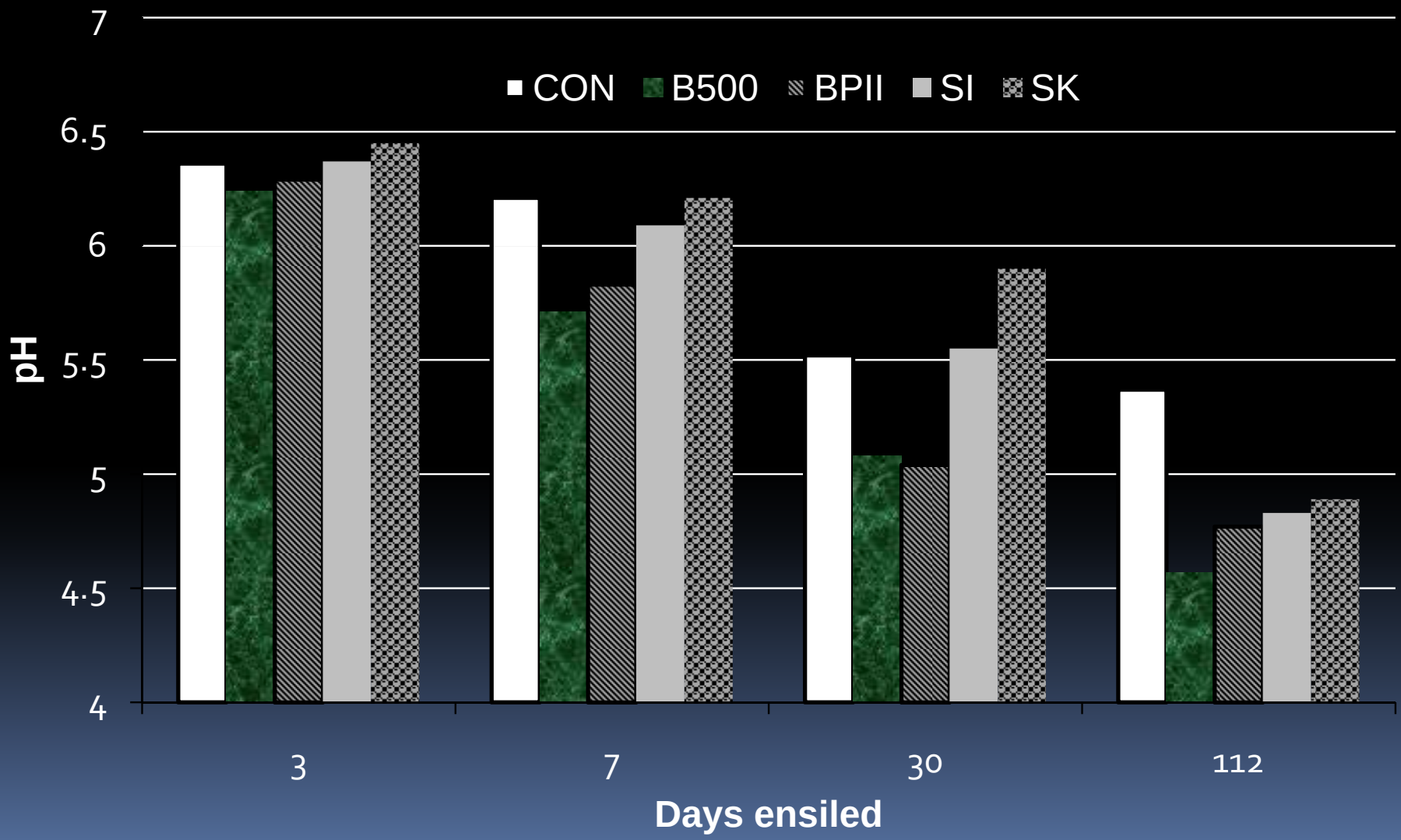
Arriola et al., 2010


INTERNAL DENSITY


Ring Power

Inoculant effects on pH

Arriola et al., 2010



Inoculant effects on spoilage organisms in bermudagrass haylage

	Control	B500	BPII	SI	SK	SEM	P value
Yeasts, log cfu,g	1.0	1.0	1.2	1.0	1.0	0.2	0.4
Molds, log cfu/g	4.62^{a}	2.35^{b}	2.81^{ab}	2.03^{b}	3.60^{ab}	1.0	0.01
Clostridia, log cfu/g	2.42^{a}	1.90^{ab}	1.81^{ab}	1.85^{ab}	1.15^{b}	0.4	0.01
Coliforms log cfu/g	1.7	1	1.4	1.7	1.4	0.9	0.80

Arriola et al., 2010

Inoculant effects on bunk life of bermudagrass haylage

Arriola et al., 2010

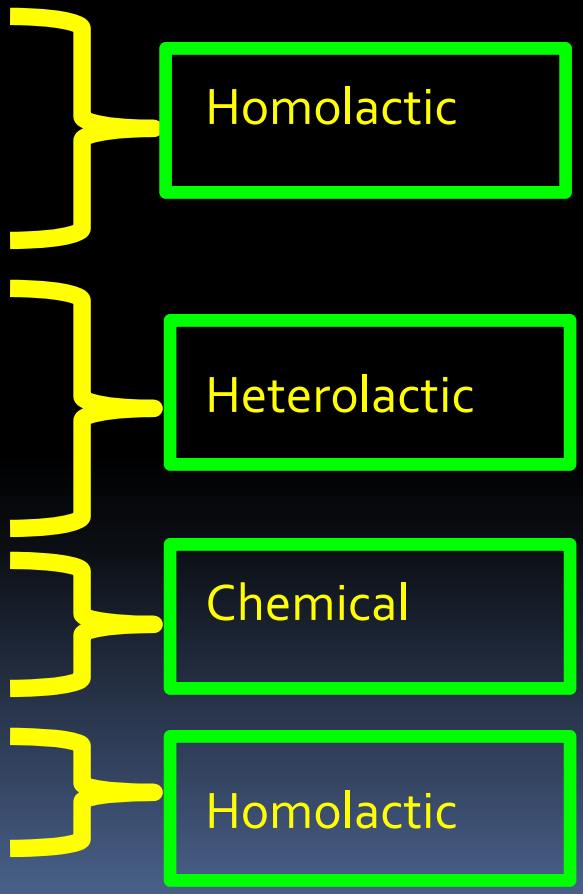
UF UNIVERSITY of FLORIDA
The Foundation for The Gator Nation

COMPARISON OF NINE ADDITIVES FOR IMPROVING SILAGE QUALITY.

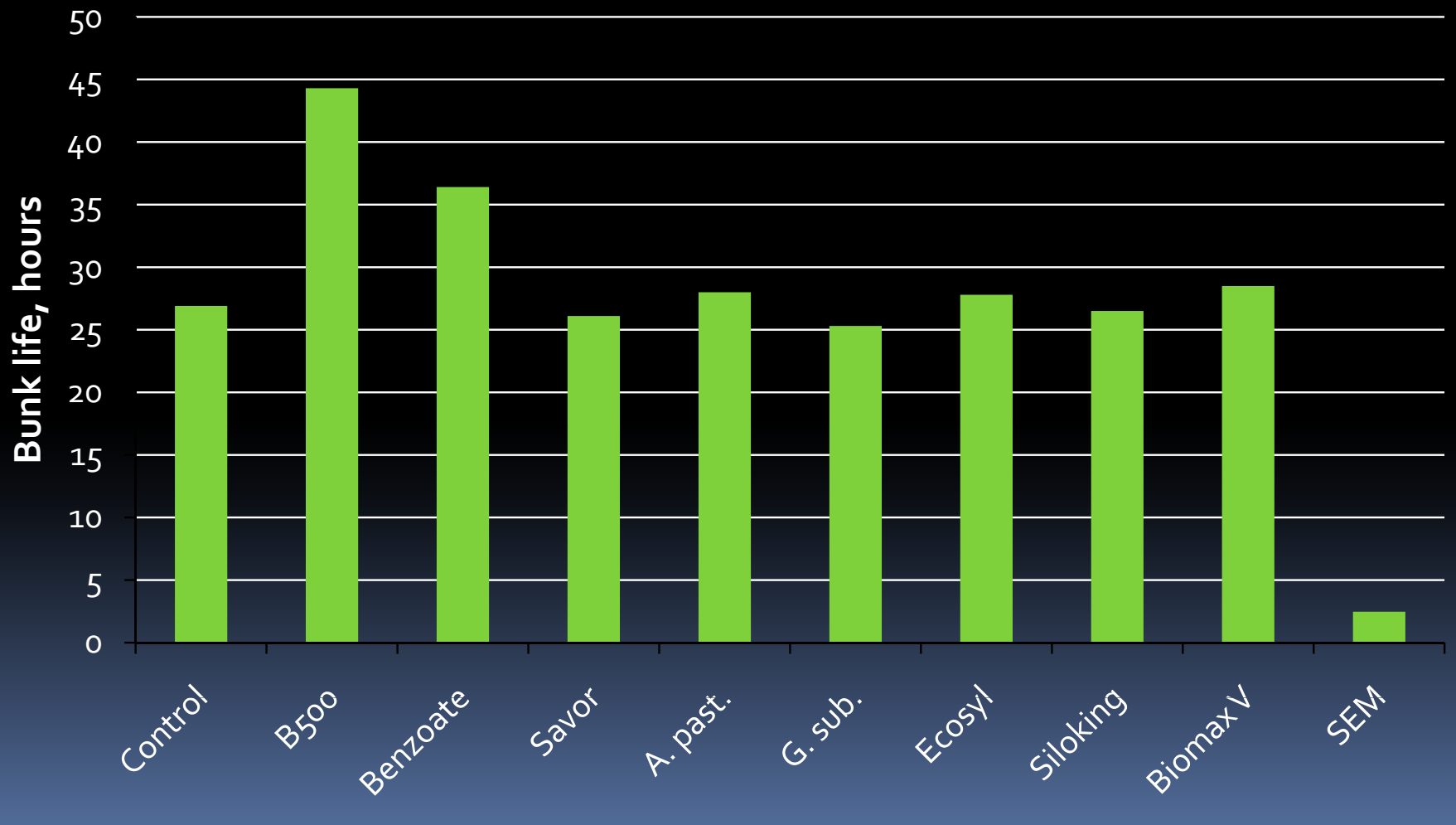
Queiroz, O.C.M., Arriola, K.G., and Adesogan, A.T.
University of Florida
Animal sciences department

Treatments

1. Control
2. L. plantarum MTD1 (Ecosyl / ADM)
3. L. plantarum PA-28 & K-270 (Biomax 5, Chr Hansen)
4. L. buchneri (Lallemand)
5. Acetic acid bacteria (New)
6. Gluconabacter (New)
7. Sodium benzoate (Chemical)
8. Acid mix (Silage savor, Kemin)
9. L. Plantarum, E. faecium and P. pentosaceus (Siloking, Agri King)



Effect of additives and inoculants on bunk life



Inoculants are also useful for:

- Wet forage
- Rainfall forages at ensiling
- Low sugar forages
- High buffering capacity forages
- High lactate forages (only heterolactics or combo)
- Stressed forage (disease, frost etc)
- Destroying pathogens
- Preventing aflatoxin production in corn

- ***Inoculants don't correct for bad management***

Conclusions

- Different types of inoculants exist.
- Many are only effective on only one phase of silage production
- Using the wrong inoculant wastes time & money
- Choose carefully

Take home messages

- Know your inoculants:
  - Use homolactics (e.g. L. plantarum) for fermentation improvement – best for grasses & legumes
  - Use heterolactics (e.g. L. buchneri) for bunk life improvement – suitable for all forages
  - Use combo inoculants for both phases – suitable for all forages
- Use inoculants only for the forages on the label

Take home messages

- Choose inoculants with at least 90 billion live bacteria / ton or 100,000 cfu/g
- Apply inoculants at the chopper, not into wagon or at bunker
- Apply them at ensiling not at feedout
- Store in a cool, dry place before use
- Do not leave inoculants in the sun or on the truck bed
- Use within 24 h after dilution.

Choose inoculants carefully

- Don’t choose by cost (price varies from 40 cents to $2 per ton);
- A 4% loss reduction achieved at least 75% of the time is necessary to breakeven with inoculant costs (Buckmaster and Lundmark, PSU)
- Choose based on efficacy in independent tests