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# Use of a heterofermentative inoculant in mixed crop corn silage

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## Introduction

- Co-cultivation of corn with flowering plants (e.g., legumes or sunflowers), that are attractive to insects, is an approach to improve the environmental impact of corn silage production
- In 2024, more than 98,000 ha (≙ 242,000 ac) mixed crop corn were grown in Germany (DMK, 2024)
- Aerobic stability of corn silage is reduced, when ensiled together with common beans (Benkner, 2020)
- Frequently, heterofermentative silage inoculants are used to improve fermentation characteristics and aerobic stability
- However, for mixed crop corn silages, there is a lack of data concerning overall silage quality and the use of inoculants

## Objectives

- Compare the composition, fermentation quality, and aerobic stability of mixed crop corn silage to that of pure corn silage
- Evaluate the response of mixed crop corn silage to a heterofermentative silage inoculant

## Materials and Methods

- Corn was planted alone (**C**) or together with common beans (**CCB**; *Phaseolus vulgaris*), field beans (**CFB**; *Vicia faba*) or sunflowers (**CSF**; *Helianthus annuus*; Figure 1)

## Materials and Methods (cont.)

- The stands were harvested in late dough stage of the corn
- One half of the material remained untreated (**Ccon, CCBcon, CFBcon, CSFcon**)
- The other half was inoculated with a mix of *L. buchneri* and *L. diolivorans* (Lactosan GmbH & Co. KG, Kapfenberg, Austria) at 2.5 × $10^5$ CFU/g FM (**Cinoc, CCBinoc, CFBinoc, CSFinoc**)
- The forages were packed into PVC mini silos (Fig. 2)

**Figure 1.** Mixed crop corn

**Figure 2.** Mini silo

- Measured parameters were: chemical composition, pH, fermentation products, counts of LAB, yeasts, mold, and clostridia, and aerobic stability (over 14 d)
- Data were analyzed using PROC MIXED in SAS (version 9.4; fixed effects: substrate, inoculation, and substrate × inoculation; random effect: mini silo)

## Results

**Table** Crude protein (CP) content and fermentation characteristics of corn silage and mixed crop corn silages after 105 d of ensiling (n=3)

| | Treatment | | | | | | | | | P-value[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Ccon | Cinoc | CCBcon | CCBinoc | CFBcon | CFBinoc | CSFcon | CSFinoc | SEM[3] | Sub (S) | Inoc (I) | S x I |
| CP, % DM | 7.04$^{d}$ | 7.10$^{d}$ | 9.70$^{a}$ | 9.74$^{a}$ | 7.43$^{cd}$ | 7.69$^{bcd}$ | 8.10$^{bc}$ | 8.58$^{b}$ | 0.199 | <0.001 | 0.160 | 0.665 |
| pH d105 | 4.01$^{cd}$ | 3.99$^{d}$ | 4.00$^{d}$ | 4.01$^{cd}$ | 4.05$^{c}$ | 4.02$^{cd}$ | 4.33$^{b}$ | 4.44$^{a}$ | 0.009 | <0.001 | 0.020 | <0.001 |
| AUC,[2] °C | 113$^{ab}$ | 52.1$^{c}$ | 110$^{ab}$ | 106$^{b}$ | 131$^{a}$ | 129$^{a}$ | 10.8$^{d}$ | 10.2$^{d}$ | 5.29 | <0.001 | <0.001 | <0.001 |
| Lactate, % DM | 4.77$^{c}$ | 4.69$^{c}$ | 7.10$^{b}$ | 6.87$^{b}$ | 4.85$^{c}$ | 5.10$^{c}$ | 12.71$^{a}$ | 12.58$^{a}$ | 0.348 | <0.001 | 0.782 | 0.793 |
| Acetate, % DM | 1.46$^{e}$ | 1.97$^{cde}$ | 2.55$^{abc}$ | 2.29$^{bcd}$ | 1.47$^{e}$ | 1.53$^{de}$ | 3.03$^{ab}$ | 3.24$^{a}$ | 0.159 | <0.001 | 0.271 | 0.146 |
| Ethanol, % DM | 0.73$^{a}$ | 0.65$^{ab}$ | 0.33$^{e}$ | 0.36$^{e}$ | 0.51$^{d}$ | 0.63$^{bc}$ | 0.53$^{cd}$ | 0.69$^{ab}$ | 0.021 | <0.001 | 0.003 | <0.001 |
| $NH_3$-N, % DM | 0.050$^{e}$ | 0.051$^{e}$ | 0.096$^{c}$ | 0.093$^{c}$ | 0.050$^{e}$ | 0.080$^{d}$ | 0.107$^{b}$ | 0.119$^{a}$ | 0.0006 | <0.001 | <0.001 | <0.001 |

$^{a–f}$ Within a row, means without a common superscript letter differ, P<0.05; [1] P-values type 3 fixed effects (Sub=substrate, Inoc=inoculation, S x I=interaction substrates x inoculation; [2] AUC=area under the curve. The AUC was calculated as the sum of the absolute change in silage temperature, relative to ambient temperature (silage temperature minus ambient temperature) over the entire length of aerobic exposure (14 d)

## Conclusion

- Mixed cropping of corn with common beans, field beans or sunflowers resulted only in moderate increases in CP
- Inoculation significantly prolonged aerobic stability of pure corn silage (+48h and smaller AUC) but was less effective in mixed silages
- Silage inoculants have to be chosen substrate specific and mixed crop corn silages differ from pure corn silages in terms of chemical composition, fermentation characteristics, and aerobic stability

**References**

Benkner F. (2020) Ensiling corn together with phaseolus beans. MSc thesis, University of Goettingen

DMK (2024) www.maiskomitee.de/Aktuelles/Mais-Gemenge-Anbau-auf-rund-4---der-Gesamtmaisflaeche-geplant

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# EFFECT OF A HOMO- AND HETEROFERMENTATIVE LACTIC ACID BACTERIA BLEND ON FERMENTATION QUALITY OF DIFFERENT SORGHUM VARIETIES

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**Keywords:** male sterile sorghum, fermentation, sorghum-sudangrass.

## INTRODUCTION

Sorghum is considered highly water-efficient and can be an alternative forage in drought-prone areas (Assefa et al., 2010). Recently, sorghum varieties available in the market has increased. Different varieties can be harvested in a wide range of moisture, being the highest values above 80%. The aim of this study was to test the effect of a mixture of homo- and heterofermentative lactic acid bacteria on fermentation of two different sorghum varieties harvested at very low dry matter.

## MATERIAL & METHODS

- Sorghum-sudangrass was harvested at approximately 13% DM and forage sorghum was harvested at approximately 16% DM. Both hybrids were harvested from 3 different field locations (used as replication; 3 mini silos per treatment combination of inoculation and storage length) at Coffey Seeds Sorghum Nursery (Plainview, TX).
- Forage was sprayed with distilled water (CON); or 150,000 cfu/g wet forage of *L. brevis, L. buchneri, L. plantarum* (PRO, bonsilage PRO, PROVITA SUPPLEMENTS, Inc.), placed in vacuum pouches and vacuum-sealed using a standard food clamp vacuum machine.
- Each silo was randomly assigned to be stored for 3, 5 and 90 d. At opening, samples were sent to Dairyland Laboratories (Watertown, WI) to be analyzed for pH, water-soluble carbohydrates (WSC), fermentation profile and ammonia-N.
- For each hybrid, data were analyzed as a completely randomized design with a 2 × 3 factorial arrangement of treatments. Inoculant, storage length and their interaction were considered fixed effects. When an interaction was detected, the effect of microbial inoculant was studied within storage length.

**Table 1.** Effect of microbial inoculant and storage length on pH, water-soluble carbohydrates (WSC), fermentation profile, and ammonia-N of sorghum-sudangrass silage stored for 3, 5 and 90 d.

| Item[1] | | pH | WSC, % DM | Lactic acid, % DM | Acetic acid, % DM | Ethanol, % DM | 1,2- propanediol, % DM | Ammonia-N, % total N |
|---|---|---|---|---|---|---|---|---|
| 3 d | CON | 4.19 | 3.84$^{b}$ | 3.50$^{b}$ | 0.58 | 0.61 | 0.00 | 1.27 |
| | PRO | 4.08 | 2.85$^{a}$ | 4.43$^{a}$ | 0.99 | 0.72 | 0.00 | 1.23 |
| 5 d | CON | 3.62$^{b}$ | 0.01 | 7.67 | 1.18 | 0.66$^{b}$ | 0.00 | 1.88 |
| | PRO | 3.15$^{a}$ | 0.01 | 7.11 | 1.00 | 0.46$^{a}$ | 0.00 | 1.97 |
| 90 d | CON | 3.75 | 0.22 | 9.25$^{b}$ | 1.42 | 0.86$^{a}$ | 0.00$^{b}$ | 3.36 |
| | PRO | 3.83 | 0.01 | 8.10$^{a}$ | 1.76 | 1.00$^{b}$ | 0.13$^{a}$ | 4.01 |
| Inoculant effect | CON | 3.85 | 1.36 | 6.80 | 1.06 | 0.71 | 0.00 | 2.17 |
| | PRO | 3.68 | 0.96 | 6.55 | 1.13 | 0.74 | 0.04 | 2.40 |
| Storage length effect | 3 d | 4.13 | 3.35 | 3.95 | 0.61$^{c}$ | 0.66 | 0.00 | 1.24$^{c}$ |
| | 5 d | 3.39 | 0.01 | 7.39 | 1.09$^{b}$ | 0.56 | 0.00 | 1.93$^{b}$ |
| | 90 d | 3.78 | 0.11 | 8.68 | 1.59$^{a}$ | 0.95 | 0.07 | 3.69$^{a}$ |
| | SEM | 0.04 | 0.13 | 0.26 | 0.11 | 0.05 | 0.03 | 0.21 |
| *P*-values | | | | | | | | |
| Inoculant | | 0.001 | 0.01 | 0.26 | 0.53 | 0.52 | 0.03 | 0.19 |
| SL | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.01 | 0.001 |
| Ino x SL | | 0.001 | 0.03 | 0.001 | 0.21 | 0.01 | 0.01 | 0.25 |

[a-b] Means with different superscripts differ within column for each storage length ($P \leq 0.05$). [2] CON – distilled water; PRO – *L. plantarum, L. brevis* and *L. buchneri* at 150,000 CFU/g of forage. SL: storage length effect: 3, 5 and 90 d.

## RESULTS

Propionic, iso-butyric and butyric acids were analyzed but not detected in any sample. Sorghum-sudangrass silage results are presented in Table 1:

- pH was similar between inoculants ($P = 0.03$) at 3 and 90 d (4.1 and 3.8, on average), while PRO had lower pH than CON at 5 d (3.2 vs. 3.6).
- PRO had lower WSC ($P = 0.03$) than CON at 3 d (2.9 vs. 3.8% of DM), however, no differences at 5 and 90 d (0.01 and 0.1% of DM, respectively).
- PRO had greater lactic acid ($P = 0.001$) at 3 d (4.4 vs. 3.5% of DM) and lower at 90 d (9.3 vs. 8.1% of DM).
- Acetic acid concentration was greater at 90 d, followed by 5 and then 3 d ($P = 0.001$; 1.6 vs. 1.09 vs. 0.61% of DM, respectively).
- CON had greater ethanol ($P = 0.01$) at 5 d (0.7 vs. 0.9% of DM) and lower at 90 d (0.9 vs. 1.0% of DM).
- PRO had greater 1,2-propanediol concentration ($P = 0.01$) at 90 d (0.1 vs. 0.0% of DM) and no differences at 3 and 5 d (0.0% of DM, on average).
- Ammonia-N concentrations were greater at 90 d, followed by 5 and 3 d ($P = 0.001$; 3.7 vs. 1.9 vs. 1.2% of total N, respectively).

Forage sorghum silage results are presented in Table 2:

- pH was lower at 5 d, followed by 90 and 3 d ($P = 0.001$; 3.4 vs. 3.6 vs. 4.0, respectively).
- PRO had greater WSC than CON ($P = 0.001$; 7.5 vs. 6.8% of DM).
- Concentrations of WSC decreased over time ($P = 0.001$; 10.4 vs. 6.6 vs 4.4% of DM, for 3, 5 and 90 d, respectively).
- Lactic acid increased over time ($P = 0.001$; 2.7 vs. 5.3 vs. 8.7% of DM, for 3, 5 and 90 d, respectively).
- Acetic acid ($P = 0.03$) was lower for PRO at 3 d (1.3 vs. 1.6% of DM) and greater at 90 d (2.5 vs. 2.1% of DM).
- Ethanol was greater for PRO ($P = 0.001$; 0.9 vs. 0.6% of DM).
- 1,2-propanediol ($P = 0.03$) was not detected at 3 and 5 d, while PRO had greater concentration than CON at 90 d (0.2 vs. 0.0% of DM).
- Ammonia-N concentrations were greater at 90 d, followed by 5 and 3 d ($P = 0.001$; 4.6 vs. 2.7 vs. 1.4% of total N, respectively).

**Table 2.** Effect of microbial inoculant and storage length on pH, water-soluble carbohydrates (WSC), fermentation profile, and ammonia-N of forage sorghum silage stored for 3, 5 and 90 d.

| Item[1] | | pH | WSC, % DM | Lactic acid, % DM | Acetic acid, % DM | Ethanol, % DM | 1,2-propanediol, % DM | Ammonia-N, % total N |
|---|---|---|---|---|---|---|---|---|
| 3 d | CON | 3.97 | 10.19 | 2.75 | 1.62$^{a}$ | 0.50 | 0.00 | 1.41 |
| | PRO | 3.98 | 10.61 | 2.62 | 1.28$^{b}$ | 0.77 | 0.00 | 1.36 |
| 5 d | CON | 3.57 | 6.17 | 5.43 | 1.83 | 0.65 | 0.00 | 2.49 |
| | PRO | 3.31 | 7.10 | 5.31 | 2.01 | 0.78 | 0.00 | 2.98 |
| 90 d | CON | 3.62 | 4.05 | 8.92 | 2.08$^{b}$ | 0.66 | 0.00$^{b}$ | 4.54 |
| | PRO | 3.59 | 4.67 | 8.44 | 2.46$^{a}$ | 0.99 | 0.16$^{a}$ | 4.56 |
| Inoculant effect | CON | 3.72 | 6.80$^{b}$ | 5.70 | 1.84 | 0.60$^{b}$ | 0.00 | 2.81 |
| | PRO | 3.63 | 7.46$^{a}$ | 5.45 | 1.92 | 0.85$^{a}$ | 0.05 | 2.97 |
| Storage length effect | 3 d | 3.98$^{c}$ | 10.40$^{c}$ | 2.69$^{c}$ | 1.45 | 0.55 | 0.00 | 1.38$^{c}$ |
| | 5 d | 3.44$^{a}$ | 6.63$^{b}$ | 5.36$^{b}$ | 1.92 | 0.61 | 0.00 | 2.74$^{b}$ |
| | 90 d | 3.61$^{b}$ | 4.36$^{a}$ | 8.68$^{a}$ | 2.27 | 0.74 | 0.10 | 4.55$^{a}$ |
| | SEM | 0.07 | 0.23 | 0.36 | 0.12 | 0.06 | 0.03 | 0.18 |
| *P*-values | | | | | | | | |
| Inoculant | | 0.15 | 0.001 | 0.42 | 0.44 | 0.001 | 0.05 | 0.30 |
| SL | | 0.001 | 0.001 | 0.001 | 0.001 | 0.10 | 0.03 | 0.001 |
| Ino x SL | | 0.18 | 0.57 | 0.85 | 0.03 | 0.44 | 0.03 | 0.29 |

[a-b] Means with different superscripts differ within column for each storage length ($P \leq 0.05$). [1] CON – distilled water; PRO – *L. plantarum, L. brevis* and *L. buchneri* at 150,000 CFU/g of forage. SL: storage length effect: 3, 5 and 90 d.

## CONCLUSION

**Despite the very low DM for both hybrids, fermentation was successful even for the CON treatment. No butyric acid was formed, probably due to favorable conditions in the mini silos. However, inoculation with PRO resulted in a more efficient conversion of WSC into organic acids, which indicates a more controlled fermentation. In addition, acetic acid and 1,2-propanediol were increased with bonsilage PRO due to the activity of *L.buchneri* and would contribute to better aerobic stability at farm level. In general, ensiling sorghum at these low DM levels should not be recommended, especially without the use of an appropriate inoculant.**

References: Assefa, Y., Staggenborg, S. A., and Prasad, V. P. V. 2010. Grain sorghum water requirement and responses to drought stress: A review. Online. Crop Management. DOI: 10.1094/CM-2010-1109-01-RV.

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# Effect of microbial inoculation, storage temperature and storage length on fermentation profile of whole-plant corn silage.

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## INTRODUCTION

- Exposure to high temperatures during fermentation can influence whole-plant corn silage (WPCS) fermentation profile and microbial activity (Bai et al., 2022).
- Research on the use of heterofermentative microbial inoculants in corn silage at high temperatures is limited and further studies are warranted.

## OBJECTIVE & HYPOTHESIS

- This study aimed to evaluate the effects of microbial inoculation, storage temperature, and storage length on the fermentation profile, microbial counts, and aerobic stability of WPCS.
- The hypothesis was that greater storage temperatures would impair fermentation, reduce aerobic stability, and increase spoilage after aerobic stability. Additionally, microbial inoculation with a combination of *L. buchneri*, *L. diolivorans* and *P. acidilactici* would increase acetic and propionic acid concentrations, as well as aerobic stability, with these effects becoming more pronounced over longer storage periods.

## MATERIALS & METHODS

- Whole-plant corn silage was harvested from four random locations (block) within a field.

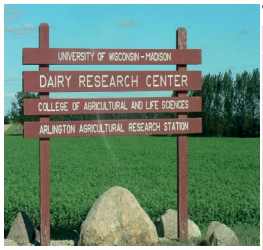
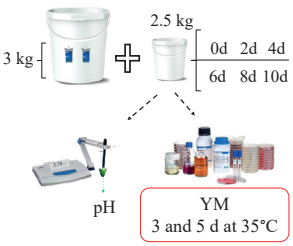



**Table 1.** Composition of fresh, uninoculated WPCS.

| Item | Average | SD |
|---|---|---|
| pH | 6.17 | 0.12 |
| DM, % as fed | 41.3 | 1.99 |
| WSC, % DM | 7.77 | 0.42 |
| CP, % DM | 7.57 | 0.35 |
| SCP, % CP | 30.2 | 2.88 |
| aNDFom, % DM | 30.8 | 3.68 |
| NDFD 30 h, % NDFom | 53.4 | 1.54 |
| uNDF 240h, % DM | 10.1 | 1.15 |
| Starch, % DM | 42.7 | 4.67 |
| StarchD 7h, % starch | 65.4 | 0.93 |
| Ash, % DM | 2.57 | 0.43 |
| Ether extract, % DM | 2.57 | 0.33 |
| LAB, log CFU/g of fresh weight | 5.49 | 0.53 |
| Yeast, log CFU/g of fresh weight | 7.19 | 0.07 |
| Mold, log CFU/g of fresh weight | 4.04 | 0.17 |

- Subsamples of 15 kg from each location were assigned to 1 of the 16 treatments which were a combination of:
  - Two microbial inoculants [control (distilled water) and LPLD (300,000 CFU/g whole-plant corn forage *of Pediococcus acidilactici* DSM 16243, *Lentilactobacillus buchneri* DSM 12856, and *Lentilactobacillus diolivorans* DSM 32074; Provita Supplements Inc.)]
  - Two storage temperatures (ST; 22 or 40 ºC)
  - Four storage lengths (SL; 7, 15, 30 and 90 d)
- Representative samples were collected for later analysis, and the remaining material was mixed and assessed for aerobic stability (temperature recorded every 30 min for 240h). The environmental temperature matched the ST (22 or 40 ºC) depending on the ST treatment.





- The storage temperature, microbial inoculation, storage length, and all their interactions were considered fixed effects, and location (replicate) was considered as a random effect. Means were compared by Bonferroni's test ($\alpha = 0.05$). If a three-way interaction was detected ($P \leq 0.05$), effects were partitioned by storage length using the SLICE option of the GLIMMIX procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC) .

## RESULTS

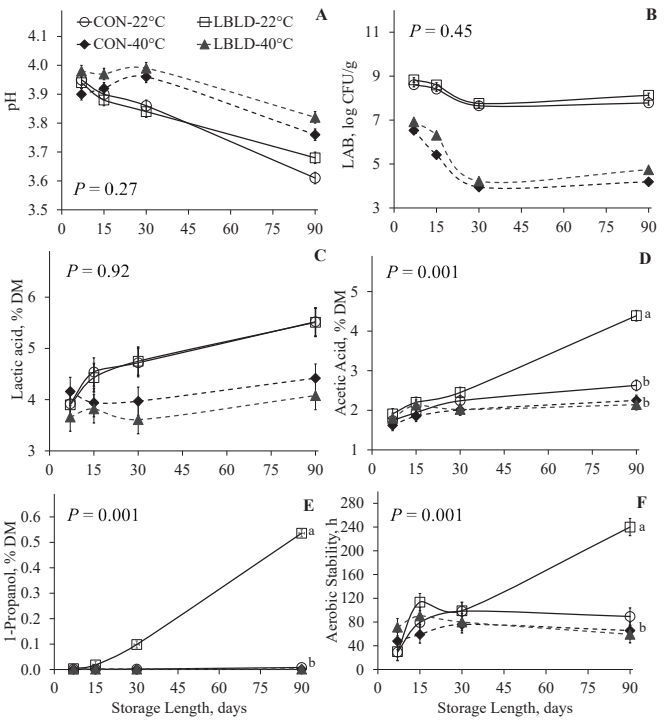



**Figure 1**. The effect of microbial inoculation (MI), storage temperature (ST), storage length (SL) on pH. LAB counts and concentrations of lactic acid, acetic acid, 1-propanol and aerobic stability of whole-plant corn silage ($n = 64$). Means within the same day with different superscripts differ ($P < 0.05$). Whole-plant corn silage was treated with distilled water (CON) or LBLD (*P. acidilactici* DSM 16243, *L. buchneri* DSM 12856, and *L. diolivorans* DSM 32074; 300,000 CFU/g forage) and stored at different ST (22 or 40°C). Silage was stored for 7, 15, 30 or 90 d. Each treatment combination of MI, ST and SL has 4 observations. Error bars represent standard error of the mean.

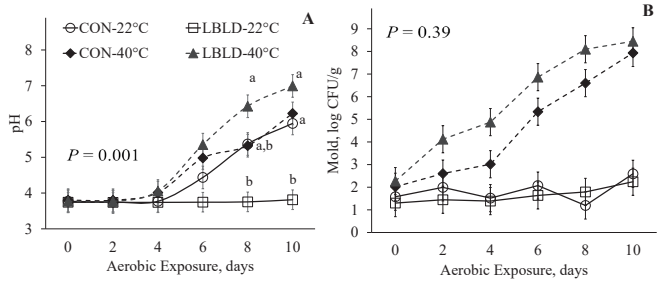



**Figure 2**. The effect of microbial inoculation (MI), storage temperature (ST), and aerobic exposure (AE) on pH and mold counts of whole-plant corn silage stored for 90 d ($n = 96$). Means within the same day with different superscripts differ ($P < 0.05$). Whole-plant corn silage was treated with distilled water (CON) or LBLD (*P. acidilactici* DSM 16243, *L. buchneri* DSM 12856, and *L. diolivorans* DSM 32074; 300,000 CFU/g forage) and stored at different ST (22 or 40 °C) for 90 d. Silage was exposed to the air for 0, 2, 4, 6, 8 and 10 d. Error bars represent the standard error of the mean.

## CONCLUSIONS

- Inoculating WPCS with a heterofermentative inoculant enhanced acetic acid concentration and improved aerobic stability for silage stored under room temperature, underscoring the effect of greater temperatures in fermentation and on the effectiveness of microbial inoculants.

## ACKNOWLEDGMENTS

- Our appreciation is extended to Provita Supplements Inc. (Mendota Heights, MN) for partially funding this study.

# EFFECT OF A MIXTURE OF HOMOFERMENTATIVE LACTIC ACID BACTERIA ON THE FERMENTATION QUALITY OF LIQUID FEED CONTAINING PEA AND LUPIN MEAL

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## BACKGROUND & OBJECTIVE

- Lactic acid bacteria (LAB) are used as inoculum to reduce substrate pH rapidly
- Pulses (e.g. beans, peas, lupins) are frequently included in pig diets in Europe. A strategy to reduce the carbon footprint of production and reduce the reliance on imported protein sources
- Liquid feeds, containing ground pulses are more difficult to acidify, due to their high protein content and buffering capacity
- Liquid feed with high crude protein content could potentially benefit from inoculation and controlled fermentation

**Objective**

Investigate the fermentation kinetics of pea and lupin meal in response to inoculation with a mixture of homofermentative lactic acid bacteria

## MATERIAL & METHODS

- A batch fermentation experiment with basic pig liquid feed rations using PVC vessels (1 L) was carried out
- Fermented liquid feed rations, containing peas mixture or lupins mixture were compared
- Inoculation treatments: (1) control (**CON**: no additive); (2) inoculated with a mixture of three homofermentative LAB (**adLAB**: *Lactobacillus paracasei, Pediococcus pentosaceus* and *Lactobacillus rhamnosus*); dosage: $2.0 \times 10^5$ CFU/g liquid feed
- The liquid feed rations were fermented at 37° C for 24 h, samples were fermented in replicates (n = 4)
- Measured parameters: pH (0 and 24 h), concentration of lactic acid, acetic acid, propionic acid, butyric acid, 1,2-propandiol, propanol, and ethanol (after 24 h)
- Data were analyzed using PROC MIXED (SAS Version 9.4). The model included the fixed effects of substrate, treatment, and their interaction. The fermentation vessels were considered a random effect.

## RESULTS

- Addition of LAB resulted in lower pH (24h) compared to CON in both liquid feed mixtures (peas and lupins, see table)
- Lactic acid concentrations in both adLAB treatments were significantly higher compared to both CON
- Adding LAB resulted in significantly lower concentrations of acetic acid, butyric acid, and ethanol in the lupin and pea mix compared to CON

**Table** Crude protein, liquid feed pH and fermentation end products (all g/kg DM) of fermented mixed liquid feed rations containing peas and lupins without (CON) and with homofermentative lactic acid bacteria (adLAB) for 24 h (n = 4)

| | Pea mix | | Lupin mix | | | P-values[4] | | |
|---|---|---|---|---|---|---|---|---|
| Item[1] | CON[2] | adLAB[3] | CON[2] | adLAB[3] | SEM | Sub[5] | Inoc[6] | Sub xTrt[7] |
| Crude protein (0h) | 208 | 208 | 313 | 313 | | | | |
| pH (0h) | 6.03[a] | 6.03[a] | 5.85[b] | 5.88[b] | 0.028 | <0.001 | 0.547 | 0.666 |
| pH (24h) | 4.57[b] | 3.87[c] | 4.76[a] | 3.90[c] | 0.017 | <0.001 | <0.001 | 0.000 |
| Lactic acid | 9.91[c] | 44.36[b] | 10.76[c] | 55.82[a] | 1.091 | 0.000 | <0.001 | 0.000 |
| Acetic acid | 10.84[a] | 0.88[b] | 11.34[a] | 1.55[b] | 0.546 | 0.304 | <0.001 | 0.878 |
| Butyric acid | 13.90[a] | 0.04[b] | 15.28[a] | 0.70[b] | 0.883 | 0.270 | <0.001 | 0.690 |
| Ethanol | 6.76[a] | 1.24[c] | 2.52[b] | 0.88[c] | 0.141 | <0.001 | <0.001 | <0.001 |

[1]Concentrations of 1,2-propandiol and n-propanol were below detection limit (<0.001 g/kg DM) in all fermentation vessels
[2]Control
[3]Both adLAB liquid feed rations were supplemented with a mixture of *Lactobacillus paracasei, Pediococcus pentosaceus, and Lactobacillus rhamnosus at* $2.0 \times 10^5$ CFU/g fresh liquid feed
[4]Within a row, means without a common superscript letter differ (P < 0.05)
[5]Substrate (Sub)) = pea mixture and lupin mixture; [6]Treatment (Trt) = CON or adLAB
[7]Interaction substrate x treatment

## CONCLUSION

Inoculation with selected homofermentative LAB (L. *paracasei, P. pentosaceus, and L. rhamnosus)* is beneficial, particularly when liquid feeds with high CP content and buffering capacity, are fermented. Fermented liquid feed pH <4.5, which is the common threshold to suppress undesired microorganisms such as enteropathogenic E. coli, Salmonella, and Klebsiella (Scholten et al., 1999), was only achieved by LAB supplementation.

Reference:
Scholten, R.H.J., van der Peet-Schwering, C.M.C., Verstegen, M. W. A., den Hartog, L. A., Schrama, J.W., Vesseur, P. C., 1999. Fermented co-products and fermented compound diets for pigs: a review. Anim. Feed Sci. Technol. 82: 1 -19.

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