Variations in fermentation, bacterial population and aerobic stability in maize silage

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Abstract

Whole crop maize in dough stage physiological maturity of grain (387 g kg^{-1} dry matter) was ensiled in big (1.2 m diameter × 1.2 m height) bales and in 3-litre mini silos with either viable lactic acid bacteria (LAB) inoculant *Lactococcus lactis* and *Lactobacillus buchneri* or without any additives. Silos were opened after 120 days, silage was sampled and the nutrient composition, fermentation products and microbial colony counts were determined. Big bale and laboratory silage was exposed to air, and aerobic stability was determined. Significant variation was observed between inoculant treated and untreated big bales, and inoculant treated and untreated laboratory silage. Viable LAB caused reduction in acidity (pH) value, a decrease in dry matter (DM) loss, concentrations of butyrate, ammonia nitrogen (NH$_3$-N) and alcohols, and an increase in the concentrations of lactic and acetic acids in both big bale and laboratory silage. Inoculated silage had lower counts of yeasts and moulds after ensiling and after air exposure, which improved their aerobic stability relative to the untreated silage. The untreated silage had a relatively large proportion of visibly spoiled silage at the surface of the big bales. The similarities observed between the big bale and laboratory silage showed that small scale silage can serve as a model for big bale silage and can be used to test the efficacy of silage additives in laboratory conditions.

Key words: aerobic stability, bales, fermentation, inoculant, laboratory silo, maize, moulds.

Introduction

Successful preservation of forage crops such as silage depends on the production of sufficient amount of organic acids in the right ratio to inhibit the activity of undesirable microorganisms under anaerobic conditions (Muck, 2012). After opening, silage exposed to air would cause rapid yeast proliferation and this could explain the rapid rise in temperature, low aerobic stability and rapid decline in sensory and nutritive quality (Dolci et al., 2011). For many years, volatile fermentation compounds, such ethanol, ammonia and organic acids, formed in silages during fermentation have been a focus of interest. Fermentation products may also contribute to poor silage and air quality under certain conditions (Hafner et al., 2013). Weiss et al. (2016) stated that badly fermented maize silage with unusual odours is associated with decreased feed intake and performance by dairy cows. Despite the fact that silages had low acidity (pH) and yeast counts were highly compacted, maize silages had high concentrations of ethanol and odorous ethyl esters (Weiss et al., 2011). All silages exposed to air more or less deteriorate as a result of aerobic yeast and fungi activity during feed-out (Schmidt, Kung, 2010, Muck, 2012). Spoilage of silage due to exposure to air decreases nutritive value and is also connected to the proliferation of potentially pathogenic or otherwise undesirable microorganisms and mycotoxin synthesis (Richard et al., 2009). Microbial additives containing lactic acid bacteria (LAB) are commonly used for silage preservation to achieve a rapid pH drop through organic acid production, and some strains have demonstrated their efficacy to improve aerobic stability and increase microbial quality of silage by inhibiting spoilage moulds and yeasts (Tabacco et al. 2011). Laboratory-scale mini silos can be particularly helpful to examine the influence of the additives on fermentation characteristics and aerobic stability of the silage and laboratory silos can serve as a model of big bale silos (Naoki, Yuji, 2008). Maize is an ideal energy crop for livestock and one of the most suitable plants for renewable energy, a fact that has been comprehensively assessed (Iqbal et al., 2014). Our aim was to examine and compare the effect of inoculating *Lactococcus lactis* and *Lactobacillus buchneri* on fermentation characteristics, microbial population and aerobic stability of whole crop maize ensiled in big bale and laboratory-scale silos.

Materials and methods

Silage preparation and experimental design. Whole crop maize (*Zea mays*, dual-purpose hybrid 'RGT Bradley') was grown at the experimental farm, Institute of Animal Science of Lithuanian University of Health Sciences. Maize was harvested at dough stage physiological maturity of grain on 26 October 2015 with a forage harvester Class Jaguar 840 ("Harsewinkel", Germany) adjusted to achieve a 10 mm theoretical cut

length. The harvested forage was immediately ensiled in big bales (1.2 m diameter × 1.2 m height) either untreated (control – T1B) or treated with the bacterial silage inoculant containing *Lactococcus lactis* and *Lactobacillus buchneri* 50:50 (T2B) at 1.5×10^5 colony forming units g^{-1} (cfu g^{-1}) of herbage. The water (T1B) or inoculant suspension (2 g product at concentration of $>0.75 \times 10^{11}$ cfu g^{-1} diluted in 4.0 L water (T2B) was sprayed during the baling process at a rate of 4 L per ton of forage using a commercial pump. Baling and wrapping of baled whole crop maize was performed using equipment Göweil LT-Master (GÖWEIL Maschinenbau GmbH, Germany). Big bales were wrapped with six layers of 0.025-mm thick and 750-mm wide white plastic film Triowrap (Trioplast AB, Sweden) to ensure anaerobic storage until opening. The 20 big bales (10 from each treatment) were marked with individual tracking numbers for later identification and were stored outside without stacking and remained undisturbed for 120 days.

For laboratory scale experiment the same chopped maize forage as for big bales was ensiled in laboratory silos of 3.0 L content. For making the treated silos the amount of chopped forage for a given silo was weighed, spread on plastic sheet and sprayed with the inoculant suspension to achieve 1.5×10^5 cfu g^{-1} of forage (T2L) or with distilled water (T1L) with a plant sprayer, thoroughly mixed and then placed into the silo with periodic tamping. Silages were made in 10 repetitions (5 for chemical and microbial analyses and 5 for aerobic stability measurement). Laboratory silos were stored for 120 days' period at a temperature of 20°C in a temperature-controlled room according to DLG-regulations for testing silage additives (DLG, 2000).

In order to determine dry matter (fermentation) losses, the small scale silos (5 from each treatment) respectively the bales (5 from each treatment) were weighed before and after the storage period. Dry matter (DM) losses were determined as the difference between the initial and final weight of each bale and were calculated as DM loss % = 100 × mass difference weight of DM kg weight^{-1} of DM kg + 2.5 based on Weißbach (2005). Due to the loss of volatiles during drying of silage samples, dry matter corrected for volatiles (DMc) was calculated according to the following equation (all concentrations expressed as g kg^{-1}):

DMc = DM + 0.95 FA + 0.08 LA + 0.77 PD + 1.00 OA, g kg^{-1} fresh matter (FM),

where FA are fatty acids (C2 … C6), LA – lactic acid, PD – 1,2-propanediol, OA – other alcohols (C2 … C4, including 2,3-butanediol) (Weißbach, Strubelt, 2008).

Sampling and analyses. Eight samples of fresh forage were taken directly from the wagon during big bale silage making time and were composited to five samples for the chemical composition, acidity (pH) and buffer capacity analyses. After storage for 120 days, five mini silos were opened and five big bales were uncovered on the same day. Eight core samples were taken from the centre of one side of each bale. Core samples were composited within the bale. One sample was taken from each laboratory silo. The samples were analysed for the dry matter content, nutrient content and fermentation parameters as well as pH, silage acids (lactic, acetic, butyric and propionic acids), alcohols and ammonia as described previously by Jatkauskas and Vrotniakienė (2013). For the LAB and the stock of yeasts and moulds counting the samples of the water and suspension used for inoculation, cooled samples of fresh forage and silage

were sent directly to a microbiological laboratory of the National Food and Veterinary Risk Assessment and LAB, yeasts and moulds were enumerated according to VDLUFA (2012), methods 28.1.1–28.1.4.

Aerobic stability measurement. After removing plastic cover from five bales, each bale was fitted with two thermocouple wires. The wires were positioned 0.30 m under the bale surface to monitor changes in bale temperature over time. Bale temperature was taken every six hours with data logging and control system MS3+ (Comet System s.r.o., Czech Republic) and evaluated for minimum, maximum and average temperature over a 39-day air exposure period. The ambient temperature was also recorded every six hours by two thermocouple wires distributed side by side of bales and protected against direct sunlight. The maximum temperature of the silage inside bales, a sum of ambient temperature, a sum of temperature of the silage in control bales and a sum of temperature of the silage in inoculated bales during exposure to air period were used to denote aerobic stability. Maximum temperature and time to reach maximum temperature were also recorded. At the start (after removing plastic cover) and at the end of the aerobic stability test, bales were rated visually for visible signs of mould growth and other signs of aerobic deterioration covering the entire surface of the bale. Any visible signs of surface deterioration were scored on a scale of 0.0 to 5.0, where 0.0 = ideal to 5.0 = moulds and other aerobic deterioration signs. At the end of aerobic stability test, big bales were individually weighed again for measuring dry matter losses during a 39-day aerobic exposure period and sampled to determine pH rise and yeast and mould counts.

For aerobic stability test on the laboratory scale, a 1000 ± 10 g sample from each mini silo (5 mini silo from each treatment) was loosely placed into a polystyrene box and allowed to aerobically deteriorate at a constant room temperature (~20°C). The top and bottom of the boxes contained a 2-cm-diameter hole to allow air to enter and carbon dioxide (CO_2) to leave. A transducer was placed in the centre of the silage mass through a hole in the cover of the box, which exposed the silage to air. The ambient temperature and the temperature of each silage were recorded every 6 hours by a screen recorder KD 7 (Lumel, Poland). The ambient room temperature was measured by using an empty control box. The aerobic stability of silages was examined by calculating the differences between the silage temperature and ambient room temperature adjusted for the base ambient temperature. The aerobic stability of the laboratory silages was defined as the number of hours the silage remained stable before rising more than a 3°C above the ambient temperature.

Statistical analysis. After analysing of data for normal distribution, the silage composition data were analysed using *PROCGLM* of *SAS* (2002), version 8.02 (SAS Institute Inc., USA), and the statistical model used was a randomized complete block. The data of aerobic stability of the silages were estimated in the following two ways: (1) hours for a 3°C increase in temperature (laboratory test) and (2) statistical analysis using a model as randomized complete block and temperature measurements data treated as repeated measurements (sets of data for every 6 hours – field test). *T*-test (LSD) was used to indicate significant differences between untreated and additive treatment. Significance was declared at $P < 0.05$.

Results and discussion

Characterization of maize crop prior to ensiling. The success of producing silage of high quality depends on two main factors, firstly, chemical composition, which determines the buffer capacity and fermentation coefficient of forage and secondly, the nature of ensiling materials, which determine the microbial population (Muck, 2013). In our study, the dry matter content of maize forage at harvest reached the value of 337.0 g kg^{-1}, crude protein concentration was 98.4 g kg^{-1} DM and water soluble carbohydrate concentration was 74.7 g kg^{-1} DM. Buffer capacity of herbage was medium – 25.98 mEq 100 g^{-1} DM, acidity (pH) – 5.88. The calculated fermentability coefficient was medium – 36.0 (DLG, 2000). Microbiological enumeration of maize forage showed that the number of LAB, yeasts and moulds was typical of the epiphytic microflora characteristics for the whole crop maize under Lithuanian conditions. The number of epiphytic LAB was 4.42 log$_{10}$ cfu g^{-1} and the number of yeasts and moulds were 4.89 and at 5.16 log$_{10}$ cfu g^{-1}, respectively, of pre-ensiled fresh matter of whole crop maize 4.89 and at 5.16 log$_{10}$ cfu g^{-1} FM, respectively.

Chemical composition, fermentation pattern and microbial properties of the silages at opening. Potentially, a difference in silage density is an important distinction between bales and can affect silage fermentation profile, dry matter loss and microbial activity (Sucu et al., 2016). In our experiment, initial bale characteristics, such as mean bale diameter, height, volume, weight and density were 1.28 and 1.24 m, 1.59 m^3, 877 kg and 170 kg m^3 DM, respectively. They were measured at the time of big bale preparation and did not differ between treatments. This verifies that the physical characteristics of the bales did not affect the chemical composition, fermentation process and microbial parameters of the silage. At silo opening (day 120 of storage) the values of chemical composition of the big bale and laboratory silage were within the range for maize silage values (Kaiser, Piltz, 2009). In inoculated big bale and laboratory silages dry matter corrected for volatiles was by 2.3% and 1.5% higher ($P < 0.05$), respectively, than the in control silages (Table 1) and that was influenced by differences in the fermentation variables (Weißbach, Strubelt, 2008).

Table 1. Chemical composition, fermentation pattern and microbial counts of the big bale and laboratory maize silages after a120-day storage period

Treatment	Big bale silage			Laboratory mini silage		
	T1B	T2B	SE	T1L	T2L	SE
Dry matter (DM) g kg^{-1}	304.9	311.1*	1.775	301.2	302.4 ns	0.760
Dry matter corrected for volatiles (DMc) g kg^{-1}	315.6	323.4*	1.722	315.9	320.7**	0.587
DM loss g kg^{-1}	85.9	54.7**	3.142	67.7	49.4**	1.536
Crude protein g kg^{-1} DM	80.0	88.8**	1.208	70.8	80.9*	2.231
Water soluble carbohydrates (WSC) g kg^{-1} DM	23.8	20.3 ns	1.559	8.4	7.9 ns	8.14
Ammonia nitrogen (NH$_3$-N) g kg^{-1} total nitrogen (N)	72.15	55.65**	2.154	81.43	61.54**	3.412
Alcohols g kg^{-1} DM	16.86	11.21**	0.949	20.63	11.45**	0.747
Lactic acid g kg^{-1} DM	22.92	39.98**	1.202	37.75	65.69**	2.403
Acetic acid g kg^{-1} DM	8.54	17.47**	0.456	19.01	33.73**	1.063
Butyric acid g kg^{-1} DM	2.20	0.37**	0.241	1.19	0.15**	0.119
Propionic acid g kg^{-1} DM	0.56	0.70**	0.080	0.82	1.27**	0.076
Acidity (pH)	4.07	3.91**	0.009	3.91	3.79**	0.013
Lactic acid bacteria (LAB) log$_{10}$ cfu g^{-1} FM	5.60	7.27**	0.162	6.69	8.14**	0.174
Yeast log$_{10}$ cfu g^{-1} FM	4.55	2.36**	0.169	3.79	1.56**	0.097
Mould log$_{10}$ cfu g^{-1} FM	2.56	1.22**	0.091	2.05	1.06**	0.051

cfu – colony forming units, FM – fresh matter; T1B – control big bale, T2B – inoculated big bale, T1L – control laboratory silos, T2L – inoculated laboratory silos; SE – standard error, * and ** – statistically significant difference $P < 0.05$ and $P < 0.01$, ns – no significance

Inoculated silage had higher content of crude protein ($P < 0.01$) and lower content of ammonium ($P < 0.01$) than the control silage which indicated that protein breakdown was restricted by LAB inoculation. Basso et al. (2014) observed that the use of silage inoculants led to a lower pH, a reduction in protein breakdown and ammonia N concentrations.

Regardless of the silo types, dry matter loss that occurred during fermentation was affected by LAB inoculation. A significant reduction in dry matter loss was found in the inoculated silage, which agrees with the findings of Carvalho et al. (2014) who reported a 29% reduction in dry matter loss compared to the uninoculated silage. Viable lactic acid bacteria treatment accelerated fermentation, as identified by the decreased pH ($P < 0.01$) at silo opening compared with the untreated control. Such shift (lower pH) in the silage with the inoculants is consistent with the summaries of studies where inoculants were successful in reducing acidity (pH) (Hu et al., 2009). Despite the silo type, when *Lactobacillus buchneri* was combined with *Lactococcus lactis*, lactic acid and acetic acid content was increased

($P < 0.01$). Hu et al. (2009) also found increases in the lactate concentration of corn silage inoculated with *Lactobacillus buchneri* and *L. plantarum* and increases in the lactic acid and acetic acid concentrations of corn silage inoculated with *L. buchneri* alone or combined with *L. plantarum*. Butyric acid content, alcohols and ammonia N concentrations were reduced ($P < 0.01$) by inoculation when compared with the control silages. Low acidity (pH) inhibit protein degradation in silages and, therefore, ammonia N concentration was lowered in the inoculated silage (Basso et al., 2014). When added to maize forage, viable LAB dominates the resulting fermentation because the counts of residual LAB after a 120-day ensiling period were significantly higher in inoculant treated silages when compared with control silage: 7.27 log$_{10}$ cfu g^{-1} *vs* 5.60 log$_{10}$ cfu g^{-1} FM ($P < 0.01$) in big bale silage and 8.14 log$_{10}$ cfu g^{-1} *vs* 6.69 log$_{10}$ cfu g^{-1} FM ($P < 0.01$) in laboratory silage. Schmidt et al. (2008) reported that numbers of LAB were markedly higher in inoculated silage compared with those in untreated silage. In the inoculated big bale silage yeast and fungi counts were significantly lower: 2.36 *vs* 4.55 log$_{10}$ cfu g^{-1} FM and 1.22

vs 2.56 $\log_{10}$ cfu g^{-1} FM ($P < 0.01$), respectively than in the untreated silages. In the treated laboratory silage count of yeasts and moulds were more than 200% and by 48.3% lower ($P < 0.01$) than in the control. Another studies (Zahiroddini et al., 2006; Schmidt, Kung, 2010) reported that inoculation with *L. buchneri* increased acetic acid concentration, decreased yeast numbers and improved the aerobic stability of wheat, sorghum and maize silages.

    Aerobic stability evaluation. The parameters used to measure aerobic deterioration were changes in temperature, pH rise, yeast and mould growth inside big bales and laboratory silos and the growth of fungi on the surface of the big bales. Penetration of air into the silage results in growth of yeasts and moulds, an increase in silage temperature and pH causing aerobic deterioration (Pahlow, Muck, 2009; Dunière et al., 2013; Weiss et al., 2016). The temperature inside silage is seen as a convenient indicator for the extent and intensity of aerobic deterioration (Borreani, Tabacco, 2010). The application of the silage inoculants gave a significant temperature response to treatment and improved the aerobic stability in the laboratory silos and the round bales. The silage without additives heated up earlier, and temperature increase was stronger in comparison to the bales or laboratory silos with inoculant (Figs 1 and 2).

    Maize silage inoculation resulted in lower maximum and sum temperatures in big bales and laboratory silos and, therefore, in lower aerobic deterioration and nutrient loss, when compared to silage without inoculants. Results suggest that the aerobic metabolism of inoculated silages reduced nutrient oxidation due to significantly less mould and yeast number in big bale and laboratory silage and significantly reduced visible mould cover being present on big bales surface (Table 2). Counts of spoilage yeast and moulds in control silage rose above target values within period of aerobic exposure. These results indicated that the tested LAB inoculant was efficient to prevent temperature increment and fungal growth during aerobic storage of maize silage. Our findings are in agreement with the report of Muck (2012), where inoculation improved the aerobic stability of the silage by causing more extensive heterolactic
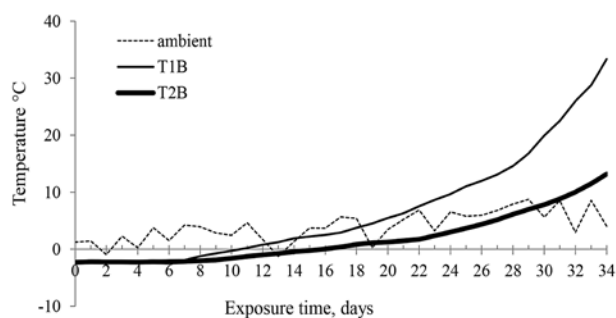
Note. The response for each big bale type is comprised of 5 bales; ambient air temperature is shown to illustrate changes in climatic conditions.

Figure 1. Temperature of the silage inside big bales control (T1B) and inoculated (T2B) during air exposure period
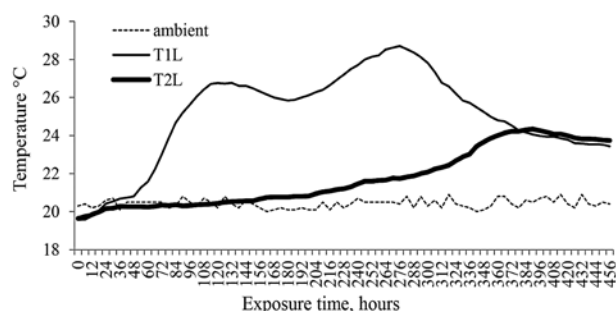

Figure 2. Temperature of the silage inside laboratory silo control (T1L) and inoculated (T2L) during air exposure period

where the improvement in aerobic stability appears to be mainly due to the reduction in yeast population during the anaerobic phase of silage conservation. *Lactobacillus buchneri* and *Propionibacterium acidipropionici* fermentation resulted in the silages with high levels of acetic and propionic acid (Filya, Sucu, 2007). Moreover, Prema et al. (2010) isolated a *Lactobacillus plantarum* strain from grass silage that produced 3-phenyllactic acid that inhibited a wide range of mould species in silage.

Table 2. Dry matter (DM) losses and microbial composition of maize ensiled in big bales and laboratory silo during exposure to air period

Treatment	Big bale silage			Laboratory mini silage		
	T1B	T2B	SE	T1L	T2L	SE
DM at aerobic exposure (AE) start g kg^{-1}	304.9	311.1*	1.775	301.2	302.4 ns	0.760
DM at AE end g kg^{-1}	288.1	301.3*	3.360	285.2	294.7 ns	3.587
DM loss during AE g kg^{-1}	24.2	12.4**	1.523	29.5	20.5**	0.980
Acidity (pH) at AE start	4.07	3.91**	0.009	3.91	3.79**	0.013
Acidity (pH) at AE end	4.93	4.31**	0.028	7.27	4.05**	0.121
Lactic acid bacteria (LAB) at AE start, $\log_{10}$ cfu g^{-1} FM	5.60	7.27**	0.162	6.69	8.14**	0.174
LAB at AE end, $\log_{10}$ cfu g^{-1} FM	5.35	7.16**	0.184	6.27	8.02**	0.099
Yeast at AE start, $\log_{10}$ cfu g^{-1} FM	4.55	2.37**	0.169	3.79	1.56**	0.097
Yeast at AE end, $\log_{10}$ cfu g^{-1} FM	8.09	3.76**	0.111	8.52	4.47**	0.124
Mould at AE start, $\log_{10}$ cfu g^{-1} FM	2.56	1.22**	0.091	2.05	1.06**	0.051
Moulds at AE end, $\log_{10}$ cfu g^{-1} FM	6.11	3.68**	0.233	7.80	4.34**	0.102
Visual mould score at AE start	0.40	0.00**	0.000			
Visual mould score at AE end	2.20	0.60**	0.042			
Aerobic stability h	406.8	715.2**	33.669	86.40	338.40**	5.724

cfu – colony forming units, FM – fresh matter; T1B – control big bale, T2B – inoculated big bale, T1L – control laboratory silos, T2L – inoculated laboratory silos; SE – standard error, * and ** statistically significant difference *vs* control $P < 0.05$ and $P < 0.01$, ns – no significance

The application of the viable LAB gave a significant response to the treatment. All the parameters used to measure aerobic deterioration: pH rise, maximum temperature above ambient and sum of temperature rise, yeast and mould population showed a good correlation with dry matter loss. The final bale and laboratory silos weight, concentration of dry matter were higher, and dry matter loss and acidity (pH) were lower for inoculated silages over exposure to air period. This is in line with the higher aerobic stability as aerobic deterioration is associated with dry matter losses (Tabacco et al., 2011).

Conclusions

Overall, it can be concluded that application of viable homo and hetero lactic acid bacteria (LAB) *Lactobacillus buchneri* combined with *Lactococcus lactis* did succeed in altering the silage fermentation profile, microbial characteristics and aerobic stability of maize ensiled in big bales and laboratory silos.

1. Inoculation increased the concentration of lactic acid and acetic acid, and decreased dry matter (DM) loss, acidity (pH), concentration of butyric acid, alcohols and ammonia. Lower yeast and mould counts in the inoculated silage at opening and after aerobic exposure period of silos correlated with a higher aerobic stability.

2. The temperature measured in the silage can be a good predictor for aerobic stability in comparison with any single silage constituent. It can be recommended to limit exposure of silage to oxygen during storage and feed-out as much as possible because of its detrimental effects on silage deterioration.

3. The similarities observed between the big bale and laboratory silage showed that laboratory silage can serve as a model for big bale silage and small scale silage can be used to test the efficacy of silage additives.

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Kukurūzų siloso fermentacijos rodiklių, bakterijų populiacijos ir aerobinio stabilumo svyravimai

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Santrauka

Kukurūzų vegetacinės masės, turinčios 387 g kg^{-1} sausųjų medžiagų, silosas buvo pagamintas dideliuose (1,2 m skersmens × 1,2 m aukščio) ritiniuose ir 3 litrų laboratorinėse talpose su gyvų pieno rūgšties bakterijų inokulianto, susidedančio iš *Lactococcus lactis* ir *Lactobacillus buchneri* kamienų, priedu arba be priedų. Siloso talpos atidarytos praėjus 120 dienų nuo silosavimo pradžios, buvo paimti mėginiai maisto medžiagų sudėčiai, fermentacijos rodikliams ir mikrobų kolonijų skaičiui nustatyti. Atrinkti siloso ritiniai ir laboratorinio siloso mėginiai buvo laikomi taip, kad į silosą laisvai patektų oras, įvertintas jų aerobinis stabilumas. Nustatytas reikšmingas rodiklių skirtumas tarp inokuliantu apdorotų ir be inokulianto ritinių bei laboratorinio siloso. Pieno rūgšties bakterijų priedas ir ritiniuose, ir laboratoriniame silose sumažino siloso sausųjų medžiagų nuostolius, rūgštumo (pH) vertę, sviesto rūgšties, amoniako bei alkoholių kiekį ir padidino pieno bei acto rūgščių koncentraciją. Ir šviežiame, ir aerobinėmis sąlygomis su inokulianto priedu laikytame silose buvo mažesnis kiekis mielių ir pelėsių. Tai lėmė geresnį siloso su priedu aerobinį stabilumą, lyginant su kontroliniu silosu. Siloso ritinių be priedų paviršius turėjo gana didelę dalį akivaizdžiai sugedusio siloso, lyginant su kontroliniu silosu. Panašumai, nustatyti tarp ritinių ir laboratorinių silosų, parodė, kad, tiriant silosavimo priedų ar kitų priemonių efektyvumą, laboratorinėmis sąlygomis pagamintas silosas gali būti modeliu dideliems ritiniams.

Reikšminiai žodžiai: aerobinis stabilumas, fermentacija, inokuliantas, kukurūzai, laboratorinis silosas, pelėsiai, ritiniai.