INFLUENCE OF SILAGE ADDITIVES ON FERMENTATION OF HIGH MOISTURE CRIMPED CORN

VPLYV SILÁŽNYCH ADITÍV NA FERMENTÁCIU VLHKÉHO MIAGANÉHO KUKURIČNÉHO ZRNA

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ABSTRACT

The objective of this work was to find influence of different silage additives on silages fermentation and nutritional value made from high moisture crimped corn, which were conserved in semi-experimental conditions. Three variants were examined, untreated control (C), and two experimental variants conserved by biological (variant A) and chemical (variant B) additives. The maize crimped corn was hermetically filled into plastic bins with the capacity 50 dm^3. In silage conserved by additives was lower content of crude fibre (significantly in both experimental variants) and higher content of nitrogen free extract, starch and total sugars (significantly in variant A) established. In silages form both experimental variants we found significantly lower content of lactic acid. The highest concent we detected in silage conserved without additives. In silage conserved by biological inoculant we found lower content of acetic acid and higher content of butyric acid, but their content was generally very low. Additives used in the experiment decreased content of amonia (0.074 g.kg^{-1} in variant A and 0.095 g.kg^{-1} of dry matter in variant B) and alcohols too.

Key words: high moisture corn, additives, nutrients, fermentation process

ABSTRACT IN SLOVAK LANGUAGE

Cieľom tejto práce bolo zistenie vplyvu rozličných silážnych aditív na fermentáciu a výživnú hodnotu siláží vyrobených z vlhkého kukuričného miaganého kukuričného zrna, konzervovaného v poloprevádzkových podmienkach. Experiment zahŕňal 3 varianty, kontrolný variant (C) – bez prídavku aditív a 2 pokusné varianty ošetrené pomocou biologických (A) a chemických (B) aditív. Kukuričné zrno bolo natlačené do plastových silážnych kontajnerov s objemom 50 dm^3 a hermeticky uzatvorené. Siláže s prídavkom aditív sa vyznačovali nižším obsahom hrubej vlákniny (preukazné v oboch variantoch) a vyšším obsahom bezdusíkatých látok výťažkových, škrobu a celkových cukrov (preukazné vo variante A). V silážach variantov A a B sme zistili nižší obsah kyseliny octovej. Jej najvyšší obsah sme zaznamenali v silážach konzervovaných bez prídavku aditív. V silážach zakonzervovaných biologickým inokulantom sme zistili nižší obsah kyseliny octovej a vyšší obsah kyseliny maslovej, pričom ich obsah bol veľmi nízky. Aditíva použité v experimente znížili obsah amoniaku (0,074 g.kg^{-1} vo variante A and 0,095 g.kg^{-1} sušiny vo variante B) a tiež alkoholov v silážach.

Kľúčové slová: vlhké kukuričné zrno, aditíva, živiny, fermentačný proces

DETAILED ABSTRACT IN NATIVE LANGUAGE

Cieľom tejto práce bolo zistenie vplyvu rozličných silážnych aditív na fermentáciu a výživnú hodnotu siláží vyrobených z vlhkého kukuričného miaganého kukuričného zrna, konzervovaného v poloprevádzkových podmienkach. Zrno kukurice bolo zberané pri vyššom obsahu vlhkosti a bezprostredne po kombajnovom zbere bolo mechanicky spracované na miagači vlhkých obilnín. Experiment zahŕňal 3 varianty, kontrolný variant (C) – bez prídavku aditív a 2 pokusné varianty ošetrené pomocou biologických (A) a chemických (B) aditív. Aditíva boli v práškovej forme a pred samotnou homogénnou aplikáciou boli rozpustené v destilovanej vode. Kukuričné zrno všetkých variantov bolo natlačené do plastových silážnych kontajnerov s objemom 50 dm^3. Fermentačný proces trval 6 mesiacov pri teplote 18-20 ^0C. Následne boli silážne kontajnery otvorené a v priemerných vzorkách sme stanovili výsledok fermentačného procesu a parametre výživnej hodnoty. Obsah sušiny sa v silážach vlhkého miaganého zrna kukurice pohyboval od 603.8 (variant C) do 612 $g.kg^{-1}$ (variant B). V obsahu sušiny, dusíkatých látok a tuku sme nezaznamenali signifikantné rozdiely. Siláže s prídavkom aditív sa vyznačovali nižším obsahom hrubej vlákniny (preukazné v oboch variantoch) a vyšším obsahom bezdusíkatých látok výťažkových, škrobu a celkových cukrov (preukazné vo variante A). V silážach variantov A a B sme zistili nižší obsah kyseliny octovej. Jej najvyšší obsah sme zaznamenali v silážach konzervovaných bez prídavku aditív. V silážach zakonzervovaných biologickým inokulantom sme zistili nižší obsah kyseliny octovej a vyšší obsah kyseliny maslovej, pričom ich obsah bol veľmi nízky. Aditíva použité v experimente znížili obsah amoniaku (0,074 $g.kg^{-1}$ vo variante A and 0,095 $g.kg^{-1}$ sušiny vo variante B) a tiež alkoholov v silážach.

Aplikáciou aditív sme v silážach vlhkého miaganého kukuričného zrna zistili preukazne vyšší obsah neštrukturálnych a nižší obsah štrukturálnych sacharidov. Z pohľadu výsledku fermentačného procesu pozitívne hodnotíme vplyv aplikácie aditív na obsah amoniaku a celkových alkoholov.

INTRODUCTION

The U.S. National Research Council (1989,1996) indicated that the energy value of high moisture corn for ruminants is slightly greater than dry gound corn.

High moisture corn is used as a high energy source in feeding rations of high productive livestock [3]. Preservation systems of high moisture maize corn have influenced favorably cattle performance [2]. To ensure good health status and high performance of cattle it is essential to produce silages with high nutrition value and meeting hygienic criteria at once. One way to eliminate undesirable effects is application of preserving additives. The most used preserving additives are organic acids that can be used separately or in combination with other acids. Similar effects have salts of these acids [1,13]. The application rate of preserving additives for high moisture corn preservation depends on moisture content [8].

Microbial inoculation that stimulates a homolactic fermentation has been shown to decrease aerobic stability too in corn silage [14]. Most biological inoculants tested on high moisture grain, and their by-products appear to have been those developed for forage applications. As these are based on lactic acid bacteria (LAB), it is hypothesized that they should promote more satisfactory lactic acid fermentation, which would improve conservation of dry matter, reduce solubilization of nitrogen and give greater aerobic stability at feed-out [15]. Microbial inoculation has improved the fermentation of silage feeds [7,9]. Microbial inoculation appears to have minimal effects on the corn silage [5,6]. Use of current available inoculants may provide insurance for storage of high moisture corn [2].

The aim of the study was to determine the effect of adding microbial and chemical additives to high moisture crimped corn, its fermentation quality and nutritional parameters.

MATERIALS AND METHODS

In semi-experimental conditions we conserved high moisture corn with different additives. High moisture corn (grain hybrid Latizana) was harvested with dry mater content between 610.7 $g.kg^{-1}$ (variant A) and 624.8 $g.kg^{-1}$ (variant B) and after the harvest was crimped with Murska 1000 HD. In experiment two different variants were examined, C – untreated control and A, B – experimental variants treated with a different biological (A) and chemical (B) additives. Additivum used in variant A contained lactic acid bacteria (Enterococcus faecium, Lactobacillus plantarum, Lactobacillus casei, Lactobacillus buchneri, Pediococcus pentosaceus, 150 x 10^3 $CFU.g^{-1}$, application ration 0.5 $l.t^{-1}$). The chemical inhibitor used in variant B containing benzoate natrium, nitrogen natrium and calcium formate (ration 3.5 $kg.t^{-1}$). Silage of both variants were conserved in PVC bags with volume capacity of 15 dm^3 in 3 repetitions (n=3). PVC bags were hermetically closed in laboratory with temperature 18-20 ^0C during six months. After the end of the fermentation process the bags were opened and in average laboratory samples parameters of nutritive value and fermentation process were determined. Organic

Table 1 Nutritive parameters of ensiled high moisture crimped corn
Tabuľka 1 Parametre výživnej hodnoty silážovaného vlhkého miaganého kukuričného zrna

n = 3		DM	CP	F	CF	A	NFE	OM	S	TS
		g.kg^{-1} of dry matter								
C	$\overline{X}$	603.8	94.9	36.2	27.6^{ab}	14.1	827.2	985.9	679.8	1.0^{a}
	s_x	1.008	1.342	5.292	1.274	1.418	0.218	0.020	0.587	0.055
A	$\overline{X}$	607.4	93.0	37.3	25.8^{ac}	13.5^{c}	830.3	986.5^{c}	690.0	6.1^{ac}
	s_x	0.333	0.788	3.392	0.671	4.330	0.079	0.059	1.002	0.094
B	$\overline{X}$	612.0	93.7	34.8	24.3^{bc}	16.5^{c}	830.8	983.5^{c}	680.6	19.99^{c}
	s_x	1.433	1.037	5.220	0.024	3.104	0.398	0.052	1.896	6.016

* DM-dry mater, CP-crude protein, F-fat, CF-crude fiber, A-ash, NFE-nitrogen free extract, OM-organic matter, S-starch, TS-total sugars
* DM-sušina, CP-dusíkaté látky, F-tuk, CF-vláknina, A-popol, NFE-bezdusíkaté látky výťažkové, OM-organická hmota, S-škrob, TS-celkové cukry
$\overline{X}$ aritmetic mean, s_x – standard deviation, $\overline{X}$ aritmetický priemer, s_x – smerodajná odchýlka
The values with identical superscript are significantly different at $P<0.05$, Hodnoty s rovnakým indexom sú preukazné pri $P<0,05$

Table 2 Result of fermentation process of ensiled high moisture crimped corn
Tabuľka 2 Výsledok fermentačného procesu silážovaného vlhkého miaganého kukuričného zrna

n = 3		DM	LA	AA	BA	FA	PA	TA	pH	NH_3	Alc.
		g.kg^{-1} of dry matter						mg KOH/100 g		g.kg^{-1} of dry matter	
C	$\overline{X}$	603.8	24.27^{b}	3.73	0.22	0.16^{b}	0.19^{ab}	1134.36^{b}	3.75^{b}	0.416	2.61
	s_x	6.087	0.678	0.267	0.012	0.035	0.012	19.707	0.006	0.565	0.566
A	$\overline{X}$	607.4	22.48^{c}	2.87	0.38	0.15^{c}	1.38^{ac}	1078.25^{c}	3.73^{c}	0.074	2.343
	s_x	2.023	1.428	0.156	0.080	0.021	0.068	45.007	0.021	0.008	0.679
B	$\overline{X}$	612.0	17.21^{bc}	3.96	0.06	1.71^{bc}	1.12^{bc}	920.20^{bc}	3.92^{bc}	0.095	1.19
	s_x	8.833	1.076	3.338	0.110	0.132	0.095	15.620	0.017	0.009	0.024

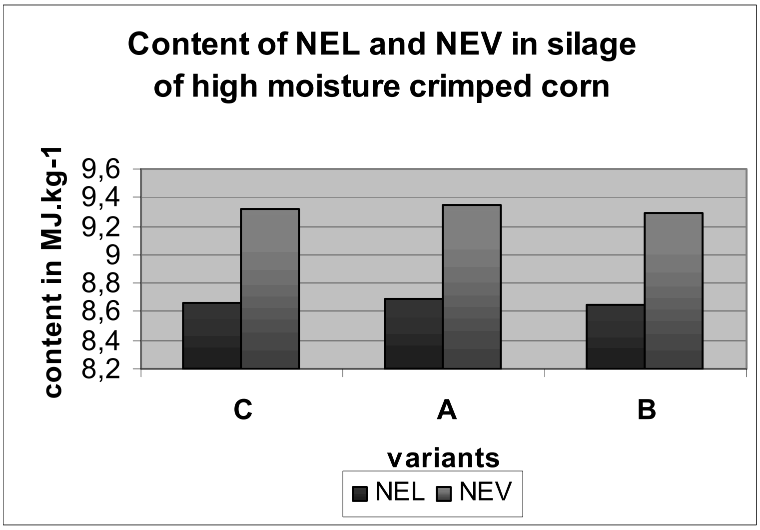
* DM- dry mater, LA- lactic acid, AA- acetic acid, BA- butyric acid, FA- formic acid, PA- propionic acid, TA- titration acidity, pH- active acidity, NH_3- amonia Alc.- alcohols
* DM- sušina, LA- kyselina mliečna, AA- kyselina octová, BA- kyselina maslová, FA- kyselina mravčia, PA- kyselina propiónová, TA- kyslosť vodného výluhu, pH- aktívna kyslosť, NH_3- amoniak, Alc.- celkové alkoholy
$\overline{X}$ aritmetic mean, s_x – standard deviation, $\overline{X}$ aritmetický priemer, s_x – smerodajná odchýlka
The values with identical superscript are significantly different at $P<0.05$, Hodnoty s rovnakým indexom sú preukazné pri $P<0,05$

nutrients were determined by Decree of the Ministry of Agriculture SR No. 2145/2004-100. Energy value (NEL, NEG) and content of really digestible protein in the small intestine (PDIN, PDIE) by Decree of the Ministry of Agriculture SR No. 39/1/200-100.

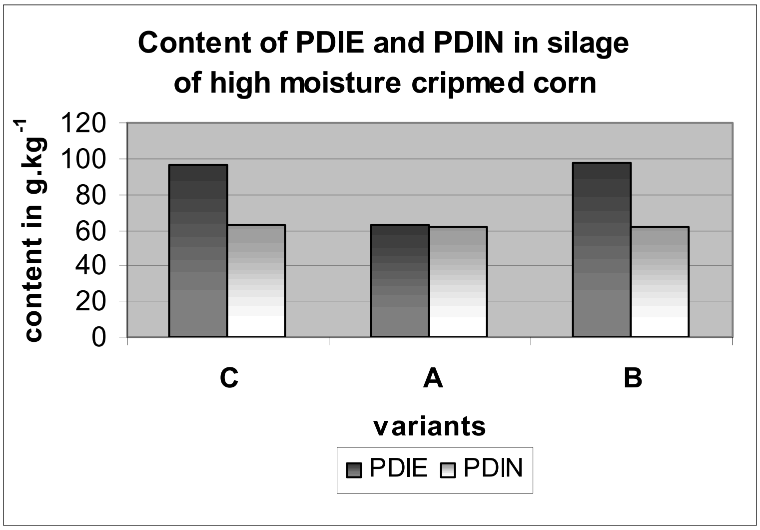
Result of fermentation was determined by analyzator EA 100 (Villa Labeco, SK). Differences between variants were tested by statistically software Statgraphics version 5.0, one factorial variance analysis (ANOVA): aritmetic mean, standard error and variation coefficient.

RESULTS AND DISCUSSION

Dry mater content in particular variants vary form 603.3 $g.kg^{-1}$ (variant C) to 612 $g.kg^{-1}$ (variant A). Buchannan et al. (2003) reported the optimum moisture of preservation grain in the range from 200 to 350 $g.kg^{-1}$ of dry mater. Content of crude protein, which are in maize corn very low (Źebrowska et al., 1997) wasn´t statistically infuenced. Crude fibre in silage of high moisture crimped corn was between 24.3 $g.kg^{-1}$ and 27.6 $g.kg^{-1}$ of dry matter. The highest content of crude fibre we found in silage made



Graph no. 1 Content of NEL and NEG in silages of high moisture crimped corn
Graf 1 Obsah NEL a NEV v silážach vlhkého miaganého kukuričného zrna



Graph no. 2 Content of PDIE and PDIN in silages of high moisture crimped corn
Graf 2 Obsah PDIE a PDIN v silážach vlhkého miaganého kukuričného zrna

without additives (variant C). In silages of experimental variants we found statistically lower content of crude fibre. Used additives influenced content of nitrogen free extract, silages conserved by additives had higher content. The highest content of this nutrient we found in silage conserved with chemical inhibitor – 830.8 $g.kg^{-1}$ of dry matter. Starch is a major nutrient of corn and corn silage too. In both experimental variants was its content higher. The highest content of starch was detected in corn silage conserved by biological additives containing homofermentative and heterofermentative lactic acid bacteria (variant A), 690 $g.kg^{-1}$ of dry matter. The similar effect we found in content of total sugars, which were from 1.0 $g.kg^{-1}$ to 19.99 $g.kg^{-1}$ of dry matter. Nutritive value of high moisture crimped corn silage is showed in table 1. The highest content of lactic acid we detected in silage of high moisture corn conserved without additives. Different results in high moisture corn conservation reported Pyrochta et al. (2005). Kung (2005) reported that in high moisture corn silage, lactic acid is normally found in the 1-3 % range. In experimental variants we found statistically lower content of this fermentation acid in variant conserved by LAB (variant A), 22.48 $g.kg^{-1}$ of dry matter. Silage of high moisture corn with addition of inhibitors at the base of organic acids and their salts (B) had the highest value of pH, and content of acetic acid too. In silage of variants C and A we found the lowest value of these fermentation process parameters. Content of acetic and butyric acid were generally low, acetic acid from 2.87 $g.kg^{-1}$ to 3.96 $g.kg^{-1}$ and butyric acid from 0.06 to 0.38 $g.kg^{-1}$. The chemical additives in silage of B variant decreased content of undesirable butyric acid (0.06 $g.kg^{-1}$ of dry matter). Content of other fermentation acid is showed in table 2. The value of pH is next qualitative parameter which we detected. In experiment were pH values from 3.73 to 3.92. The differences were significantly. After the additives application and finish of fermentation process we found lower content of amonia, 0.074 $g.kg^{-1}$ and 0.095 $g.kg^{-1}$ of dry matter. The similar effects in ensiled high moisture corn silage reported Dolezal and Zeman (2005).

CONCLUSION

Different types of preserved additives influenced the fermentation process quality of high moisture corn. Treatment with a biological additive containing lactic acid bacteria stimulated fermentation, resulting in lower concentrations of acetic acid and value of pH. After the application of chemical additive the high moisture corn had the significantly lower content of lactic acid and the highest value of pH. After the fermentation process we found in both expermental variants significantly higher content of propionic acid. Silage additives most influenced nutritional characteristics. In silage of high moisture corn conserved by biological and chemical additives we found lower content of crude fibre, which is in negative correlation with digestibility of feed nutrients, and higher content of non-fibre carbohydrates.

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