Slovak J. Anim. Sci., 40, 2007 (1): 30 - 33
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EFFECT OF COMBINED BIOCHEMICAL ADDITIVES ON NUTRITIVE VALUE AND FERMENTATION PROCESS OF ENSILED CRIMPED HIGH MOISTURE CORN

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ABSTRACT

The aim of our work was to find the influence of combined biochemical additives on nutritive value and fermentation process of high moisture corn (HMC). In the experiment we used corn with high content of moisture, ranging from 608.9 to 613.3 g. After harvesting, corn was directly crimped on crusher. Two different variants of HMC were examined: K – untreated control and A – treated with combined additives containing lactic acid bacteria, enzymatic complex of cellulases and natrium benzoate. After six months the average samples were evaluated for content of nutrients and parameters of nutritive value. Addition of silage conservants decreased the content of crude fibre ($p<0.01$) through cellulases. Lactic acid bacteria had positive effect on starch content ($p<0.01$) and total saccharides ($p<0.001$). Quality of fermentation process affected the additives statistically, particularly in regards of significant lower content of acetic acid ($p<0.05$) and higher content of propionic acid ($p<0.01$) which has marked fungicidal characteristics. In silage of experimental variant A we found significantly lower value of pH ($p<0.05$).

Key words: conservation, high moisture corn, silage additives, nutritive value, fermentation process

INTRODUCTION

Maize (*Zea mays*) represents a decisive source of energy in feeding rations for ruminants in Slovakia. Generally feeds are produced with different nutritional and hygienic paramaters. The differences are above all in energy value (Bíro, 2001). It is the enegy that limits the nutritive value of feed (Hoffmann, 1988). During the period of harvest, technology of high moisture corn was economically more efficient for lower losses and processing costs (Volkov et al., 1999; Bíro and Juráček, 2003). High moisture corn has higher nutritive value and higher digestibility of organic matter when compared with dry corn (Woodacre, 2004). For better results of fermentation process in high moisture corn conservation, we used different silage additives. For example, biological inoculants containing lactic acid bacteria, which produce lactic acid, are suitable. Nutritive value, sensory characteristics and durability of fermented feed is under the influence of quantity of lactic acid (Kozáková et al., 1999). Highly effective are also the chemical inhibitors including organic acids or their salts. Chemical inhibitors have typical fungicidal impacts (Bíro and Juráček, 2003). Pyrochta and Doležal et al. (2005) reported effective elimination of organic acids on species representation of feed microflora.

Both high moisture corn and corn silage in the form of fermented feed are frequently used in beef and dairy rations across the world (Tapia et al., 2005).

MATERIAL AND METHODS

In semi-experimental conditions we conserved the corn with high content of moisture, which was mechanically processed by crusher MURSKA 1000 HD. High moisture corn was harvested at the content of dry matter from 608.9 to 613.3 g. Material for experiment was obtained from Slovak Agricultural University,

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ISSN 1335-3686

Experimental farm in Kolinany. Experiment consisted of two variants, control (without preservative agents) and experimental variant A. In silage of variant A we applied combined biochemical additives that contained lactic acid bacteria (*Lactobacillus plantarum CCM 3796, Enterococcus faecium CCM 6226, Pediococcus pentosaceus CCM 3770, Lactococcus lactis CCM 4754)*, active complex of cellulases and natrium benzoate in dose 6 $l.t^{-1}$. We preserved both variants into PVC bins of 50 dm^3 volume which were hermetically maintained. After six months we opened the bins and from average samples we evaluated parameters of nutritive value and fermentation process (according to the Regulation of Ministry of Agriculture of the Slovak Republic dated 2145/ 2004 – 100). We detected content of dry matter by drying (t 103±2 ^{0}C), crude protein by Kjeldahl method, fat extractive by Soxhlet apparatus, crude fibre after acidodetergent hydrolysis, ash by burning (t 530± 20^{0}C), starch by polariscope and we calculated the nitrogen free extract. We analysed organic acids with analyzer EA 100 (Villa Labeco) by ionic electrophoresis method. We calculated parameters of nutritive value after Petrikovič and Sommer (2002). For mathematic-statistical analysis we used the method of one factorial variance analysis using software programme Statgraphics version 5.0.

RESULTS AND DISCUSSION

Dry matter content of high moisture corn in particular variants varied from 613.3 (control) to 608.9 $g.kg^{-1}$ in variant A (Table 1). Identical results were reported by Mader et al. (1983) and Mlynár et al. (2006) which conserved high moisture corn by 550 and 650 $g.kg^{-1}$ of dry matter content. After the end of conserved fermentation process we found in average samples the contents of dry matter 603.8 (control) and 596.6 $g.kg^{-1}$ in experimental variant A (Table 2).

Doležal and Zeman (2005) found in biological untreated high moisture corn silage average content of dry matter 603.4 $g.kg^{-1}$. Źebrowska et al. (1997) and Abdelhadi et al. (2005) found content of crude protein in corn to be around 100 $g.kg^{-1}$ of dry matter. After applying biochemical additives we identified decreased content of crude protein and the same content of fat. As for the content of crude fibre, which is in negative correlation with digestibility of organic matter, we detected in silage of variant A statistically significant lower content ($p<0.01$). This effect was produced by enzymatic component of additives (complex of cellulases). For stimulating fermentation process lactic acid bacteria (LAB) are very important. LAB transformed part of plant carbohydrates into lactic acid with considerable conservation impacts (Kozárová et al. 1999). LAB take the advantage of nitrogen free extract (NFE). In silage of experimental variant (A) we found statistically higher content of NFE ($p<0.01$) as effect of lower losses. From nutritive aspect corn cereal is valuable as elementary source of energy. It has high content of energy determined by content of starch. In silage of control variant (K), we recorded 679.8 $g.kg^{-1}$ of starch as dry matter. In silage of experimental variant A we found significantly ($p<0.01$) higher content of starch (698.6 $g.kg^{-1}$ of dry matter). Content of total sugars is substantial for energetic value of feed. Influence of experimental additives on their content was statistically significant ($p<0.001$). In fermentation process we assessed content of lactic acid, acetic acid, propionic acid and butyric acid (Table 3). In confrontation with control variant silage we found in silage of experimental variant significantly lower content of acetic acid ($p<0.05$) and the same content of undesirable butyric acid (0.22 $g.kg^{-1}$ of dry matter). Content of propionic acid with considerable fungicidal characteristics (Bíro, Juráček, 2003) was recorded in silage of variant A as statistically higher ($p<0.001$). Additives positively influenced value of pH ($p<0.05$). Additives similarly infuenced proteolysis too.

CONCLUSION

The applied silage conservants influence the final nutritive value and fermentation process of conserved feed. The additives used consisted of lactic acid bacteria (LAB), active complex of cellulases and natrium benzoate, positively affected several nutritive characteristics of conserved crimped high moisture corn, above all the content of saccharides, fermentation of carboxylic acids, more specifically active acidity (pH).

ACKNOWLEDGEMENT

This study was supported by Scientific Grant Agency of the Ministry of Education (1/2429/05).

Table 1: Characteristic of fresh high moisture corn

n =1	DM	CP	F	CF	A	NFE	OM	S	T.s.	NEL	NEG	PDIE	PDIN
	g.kg^{-1} of dry matter									MJ.kg^{-1} of dry matter		g.kg^{-1} of dry matter	
K	613.3	91.7	42.4	31.8	16.6	817.5	983.4	666.8	28.65	8.68	9.33	98.3	60.3
A	608.9	89.9	37.8	29.4	15.2	827.6	984.8	643.8	30.84	8.67	9.32	98.4	59.2

* DM – dry matter, CP – crude protein, F – fat, CF – crude fibre, A – ash, NFE – nitrogen free extract, OM – organic matter, S – starch, T.s. – total sugars, NEL – net energy for lactation , NEG – net energy gain, PDIE, PDIN – protein digestible in intestine

Table 2: Characteristics of high moisture corn silage

n =3		DM	CP	F	CF	A	NFE	OM	S	T.s.	NEL	NEG	PDIE	PDIN
		g.kg^{-1} of dry matter									MJ.kg^{-1} of dry matter		g.kg^{-1} of dry matter	
K	$\bar{x}$	603.8	94.9	36.2	27.6	14.1	827.2	985.9	679.8	1.0	8.66	9.32	96.97	62.5
	s	6.087	1.274	1.916	0.351	0.200	1.800	0.200	3.988	0.001	0.015	0.021	0.351	0.814
	v	1.008	1.342	5.292	1.274	1.418	0.218	0.020	0.587	0.055	0.176	0.223	0.362	1.304
A	$\bar{x}$	596.6	92.5	36.2	23.5	13.5	834.3	986.5	698.6	3.1	8.70	9.37	96.60	60.8
	s	2.021	0.485	1.301	0.100	0.462	1.418	0.462	6.538	0.015	0.010	0.012	0.321	0.306
	v	0.339	0.495	3.592	0.426	3.413	0.170	0.047	0.936	0.495	0.115	0.123	0.333	0.502
K:A		-	-	-	++	-	++	-	++	+++	-	-	-	-

+ P< 0.05 ++ P< 0.01 +++ P< 0.001

* DM – dry matter, CP – crude protein, F – fat, CF – crude fibre, A – ash, NFE – nitrogen free extract, OM – organic matter, S – starch, T.s. – total sugars, NEL – net energy for lactation , NEG – net energy gain, PDIE, PDIN – protein digestible in intestine

Table 3: Results of fermentation process of high moisture corn

n=3		DM (g.kg^{-1})	Content of acids (g.kg^{-1} of dry matter) LA	AA	PA	BA	NH_3	OH	TA	pH
							g.kg^{-1} of dry matter		mg KOH/ 100g	
K	$\bar{x}$	603.8	24.27	3.73	0.19	0.22	0.416	2.61	1134.36	3.75
	s	6.087	0.678	0.267	0.012	0.012	0.565	0.566	19.707	0.006
	v	1.008	2.792	7.149	5.973	5.170	1.357	2.166	1.737	0.154
A	$\bar{x}$	596.6	22.96	2.82	1.36	0.22	0.094	2.22	1077.64	3.70
	s	2.021	0.583	0.078	0.046	0.021	0.022	0.512	25.302	0.012
	v	0.339	2.538	2.751	3.370	9.321	22.956	23.070	2.359	0.312
K:A		-	+	+	+++	-	-	-	++	+

+ P< 0.05 ++ P< 0.01 +++ P< 0.001

* DM – dry matter, LA – lactic acid, AA – acetic acid, PA – propionic acid, BA – butyric acid, NH_3 – ammonia, OH – content of total alcohols, TA – titration acidity, pH – active acidity

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