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THE QUALITY OF FERMENTATION PROCESS OF HIGH MOISTURE CRIMPED CORN

KAKVOĆA FERMENTACIJE VISOKO VLAŽNOG TIJEŠTENOG KUKURUZA

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SUMMARY

The objective of this research was to find the influence of different silage additives on the quality of fermentation process of ensiled high moisture crimped corn. Three variants were examined: untreated control (UC) variant in which was high moisture corn conserved without additives, and experimental variants A and B. In these variants different silage additives (bacterial inoculant in variant A and combined biochemical additive in variant B) were applied. After 6 months of silage fermentation process the average samples for the fermentation products content were determined. The highest lactic acid content was found in untreated control variant (24.27 g/kg of dry matter). After the silage additives application lower acetic acid content was found (2.87 in variant A and 2.82 g/kg of dry matter in variant B). Undesirable butyric acid content was generally very low. The lowest value (significantly at $P<0.01$) of titration acidity was determined in variant B. The value of active acidity (pH) of water extracts of silages were from 3.70 (variant B) to 3.75 (variant UC), without statistical differences. In variants conserved by additives lower ammonia content as well as total alcohols were found. In comparison with untreated variant (UC) we didn't find in top of silage profiles of experimental variants B sensory occurrence of fungi.

The application of combined biochemical additive influenced the quality of fermentation process more positively for higher lactic acid content and the lowest acetic acid content, titration acidity and the value of pH, than bacterial inoculant.

Keywords: silage, high moisture corn, fermentation process, fermentation products

INTRODUCTION

On the world basis, maize corn is the most important feed in livestock feeding. Having a high available energy content and a relatively low protein

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content, it has usually been looked on mainly as an energy source in a diet (Summers, 2001). Juracek et al. (2006) reported, that maize was the most important crop for animal nutrition in the Slovak Republic.

High moisture corn is used as a high energy source in feeding rations of high productive livestock (Dixon, Stockdale, 1999). In comparison with dry maize corn typical higher content of nutrients and higher digestibility of organic matter of feed are for high moisture. It possible to conserve maize with high moisture content as a whole or mechanically processed, crimped (Mader et al. 1983).

For better results in fermentation process in high moisture corn conservation the application of additives is needed. Several chemicals have been evaluated, usually with the objective of preventing growth of undesirable mircoorganisms and heating and spoilage (Jones et al., 1974). Silage additives contain organic acids or their salts which are very effective for their typical fungicidal and bactericidal properties (Biro et al., 2006). Sometimes they are used in mixtures or separately.

MATERIAL AND METHODS

In semi-experimental conditions we conserved maize with a high moisture content. After the harvest with a combine maize was immediately mechanically processed by the MURSKA 1000 HD crusher. High moisture corn was harvested at the dry matter content from 608.9 to 613.3 g. Material for the experiment was obtained from the Slovak Agriculture University, Experimental farm in Kolinany. The experiment consisted of three variants, control (without preservative agents) and experimental variants A and B. The silages of variant A were conserved with a biological inoculant with homo-fermentative and heterofermentative species of lactic acid bacteria (*Lactobacillus rhamnosus*, *Lactobacillus plantarum*, *Lactobacillus brevis*, *Lactobacillus buchneri* a *Pediococcus pentosaceus*: 2.5 x 10^{11} CFU.g^{-1}), dose 0.5 l/t. In variant B 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. We preserved both variants in PVC bins of 50 dm^3 volume which were hermetically closed. After six months we opened the bins and in average samples we detected parameters of nutritive value and fermentation process (according to the Regulation of Ministry of Agriculture of the Slovak Republic on 2145/ 2004 – 100). We analysed organic acids (lactic acid, acetic acid, butyric acid, propionic acid and formic acid) with the analyzer EA 100 (Villa Labeco) by ionic electrophoresis method. Total alcohols and ammonia were detected by microdifussion method, titration acidity and active acidity as well as alcalimetric titration by electro-metric method. We calculated parameters of nutritive value by Petrikovič and Sommer (2002). For mathematical-statistical results we used the method of one factorial variance analysis in the software program *Statgraphics* version 5.0.

RESULTS AND DISCUSSION

After the storage (6 months) we detected in silages of high moisture crimped corn the dry matter content between 596.6 (variant B) and 607.4 g/kg (variant A). The highest desirable lactic acid content we found in silages of variant without additives addition. In other variants the lactic acid content was from 22.48 g/kg of dry matter to 22.96 g/kg of dry matter (B). Different results reported Pyrochta et al. (2005). These authors found in silages of high moisture crimped corn after the application of additives significantly higher lactic acid content. The acetic acid content as well as the butyric acid content were in all variants of the experiment very low which is shown in table 1. A lot of differences between variants we determined in the value of titration acidity. Silages of variants conserved with biological or biochemical additives have lower titration acidity (significantly in variant B), 1078.25 mg (variant A), 1072.64 mg KOH (variant B). Value of active acidity (pH) is one of more limiting factors, that influence the quality of ensiled feeds (Gálik, 2007). In analyzed silages pH was from 3.70 (variant B) to 3.75 (variant UC). The application of silage additives positively influenced the total alcohols content as well. For silages of experimental variants

(A, B) lower content was typical. Driehuis et al. (1999) the same results published. For fermentation process stimulation bacterial inoculant application is needed for *Coli aerogenes* inhibition. In silages conserved with biological (variant A) or biochemical additives (variant B) we found lower ammonia content. The same ammonia content in the silage of high moisture crimped corn conserved without additives was found by Doležal and Zeman (2005). In comparison with their results, we found, after the silage additives application, lower ammonia content in biologically and biochemically conserved high moisture crimped corn. In silages conserved with biochemical additives we didn't find occurrence of fungi in top of silage profile after subjective evaluation.

Table 1. Result of fermentation process of different ensiled high moisture crimped corn
Tablica 1. Rezultati procesa fermentacije tiještenja visoko vlažnog kukuruza

n = 3		DM	LA	AA	BA	FA	PA
		g/kg	g/kg of dry matter				
UC	$\bar{x}$	603.8	24.27^{a}	3.73^{a}	0.22	0.16	0.19^{ab}
	s_v	6.087	0.678	0.267	0.012	0.035	0.012
A	$\bar{x}$	607.4	22.48	2.87	0.38	0.15	1.38^{b}
	s_v	2.023	1.428	0.156	0.080	0.021	0.068
B	$\bar{x}$	596.6	22.96^{a}	2.82^{a}	0.22	0.17	1.36^{a}
	s_v	2.021	0.583	0.078	0.021	0.015	0.046

* DM: dry matter, LA: lactic acid, AA: acetic acid, BA: butyric acid, FA: formic acid, PA: propionic acid
* The values with identical superscripts are significant at $P < 0.05$

Table 2. Result of fermentation process of different ensiled high moisture crimped corn
Tablica 2. Rezultati procesa fermentacije tiještenja visoko vlažnog kukuruza

n = 3		TA	pH	NH_3	OH^-
		mg KOH		mg/kg of DM	g/kg of DM
UC	$\bar{x}$	1134.36^{a}	3.75^{a}	0.416	2.61
	s_v	1.707	0.006	0.565	0.566
A	$\bar{x}$	1078.25	3.73	0.074	2.43
	s_v	5.007	0.021	0.008	0.679
B	$\bar{x}$	1072.64^{a}	3.70^{a}	0.094	2.22
	s_v	5.302	0.012	0.022	0.512

* TA: titration acidity, pH: active acidity, NH_3: ammonia, OH^-: total alcohols
* The values with identical superscripts are significant at $P < 0.05$

CONCLUSIONS

In semi-experimental conditions we silaged high moisture corn with bacterial and biochemical additives. For silages which we conserved with additives the lowest acetic acid content was typical (significantly in variant with biochemical additives). The application of different silage additives influenced the value of pH. In silages with additives we found lower values of pH, significantly in variant with biochemical additives. We also found a positive effect of additives in the ammonia and total alcohols content. After opening the silage bags we subjectively determined hygienic quality of silages. In silages of variant conserved with biochemical additives we didn't find in top of silage profiles sensory occurrence of fungi. The application of biochemical additives influenced the quality of fermentation process and hygienic quality more positively than bacterial inoculant.

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REFERENCES

1. Bíro, D., Juráček, M., Gálik, B., Šimko, M., Kačaniová, M. (2006): Influence of chemical inhibitors on fermentation process and hygienic quality of high moisture corn. Slovak Journal of Animal Science 39 (1-2) 108-112.
2. Dixon, R.M., Stockdale, C.R. (1999): Associative effects between forages and grains: consequences for feed utilization. Australian Journal of Agriculture Research 50 757-773.
3. Doležal, P., Zeman, L. (2005): Effects of different forms of bacterial inoculants on the fermentation process of ensiled crushed maize moisture grains. Czech Journal of Animal Science 50 201-207.
4. Driehuis, F., Van Wikselaar, P. G. (1999): The prevention of alcoholic fermentation in high dry matter grass silage. The XXIIth International Silage Conference, Uppsala, Sweden
5. Gálik, B. (2007): Nutričná hodnota biologicky a chemicky konzervovaného vlhkého zrna kukurice. Dizertačná práca. Nitra: Slovenská poľnohospodárska univerzita, 1-170.
6. Juráček, M., Bíro, D., Gálik, B., Šimko, M., Ložek, O. (2006): Nutritive value of maize silage with different nitrogen fertilization intensity. 12th International Symposium Forage Conservation. Brno: University of Veterinary and Pharmaceutical sciences.
7. Jones, G. M. (1974): Organic acid preservation of high moisture corn and other grains and the nutritional value: a rewiew. Canadian Journal of Animal Science 54 499-517.
8. Mader, T., Guyer, P., Stock, R. (1983): Feeding high moisture corn. In NebGuide: University of Nebraska, Lincoln [online]. 1983 [cit. 2004-06-14], available in internet: http://ianrpubs.unl.edu/Beef/g100.htm
9. Pyrochta, V., Doležal, P., Doležal, J. (2005): Vliv směsi organických kyselin a mikrobiálního inokulantu na fermentační proces laboratorních siláží z mačkaného vlhkého zrna kukuřice. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 35 107-115.
10. Ray, L. L., Bullermann, L.B. (1982): Preventing growth of potentially toxic molds using antifungal agents. Journal of Prod. Agriculture 45 953-963.
11. Summers, J. D. (2001): Maize: Factors affecting its digestibility and variability in its feeding value. Bedford, M.R., Partridge, G. G.: Enzymes in farm animal nutrition, Wallingford: CABI Publishing, 109-124.

SAŽETAK

Cilj ovog rada bio je ustanoviti utjecaj raznih silažnih dodataka na kakvoću procesa fermentacije visoko vlažnog tiještenog kukuruza. Ispitane su tri varijante: netretirana kontrolna varijanta (UC) u kojoj je sačuvan vrlo vlažan kukuruz bez dodataka i pokusne varijante A i B. U tim varijantama primijenjeni su različiti dodaci silaži (bakterijsko cjepivo u varijanti A i kombinirani biokemijski dodatak u varijanti B). Nakon 6 mjeseci procesa fermentacije silaže određeni su prosječni uzorci za sadržaj produkata fermentacije. Najveći sadržaj mliječne kiseline nađen je u netretiranoj

kontronoj varijanti (24.27 g/kg suhe tvari). Nakon primjene dodataka u silaži nađen je manji sadržaj octane kiseline (2.87 u varijanti A i 2.82 g/kg suhe tvari u varijanti B). Sadržaj nepoželjne maslačne kiseline uglavnom je bio vrlo nizak. Najniža vrijednost (nivo značajnosti $P<0.01$) titracijske kiseline ustanovljena je u varijanti B. Vrijednost aktivne kiseline (pH) vode ekstrakata silaže bila je od 3.70 (varijanta B) do 3.75 (varijanta UC) bez statistički značajnih razlika. U varijantama konzerviranim dodacima nađen je manji sadržaj amonijaka kao i ukupnih alkohola. U usporedbi s netretiranom varijantom (UC) na vrhu silaža pokusne varijante B nije nađena senzorna pojava gljivica.

Primjena kombiniranih biokemijskih dodataka utjecala je pozitivnije od bakterijskog cjepiva na kakvoću procesa fermentacije za veći sadržaj mliječne kiseline i najmanji sadržaj octane kiseline, maslačne kiseline i vrijednosti pH nego li bakterijsko cjepivo.

Ključne riječi: silaža, kukuruz velike vlažnosti, process fermentacije, proizvodi fermentacije