10.7251/AGSY1203460D
UDK 636.085.52

MODERN PROCEDURES TO INCREASE AND PRESERVE THE NUTRITIONAL VALUE OF THE CORN SILAGE

Nenad DJORDJEVIC[1*], Goran GRUBIC[1], Bora DINIC[2], Bojan STOJANOVIC[1], Aleksa BOZICKOVIC[1], Aleksandra IVETIC[1], Nenad MILENKOVIC[3]

[1]University of Belgrade, Faculty of Agriculture, Serbia,
[2]Institute for Forage Crops, Krusevac, Serbia
[3]Municipal Assembly of Velika Plana
(Corresponding author: nesadj@agrif.bg.ac.rs)

Abstract

In this paper we have given the review of domestic as well as foreign experiences connected to increasing of the protein amount and aerobic stability of corn silage.

Today corn silage is the base of intensive and economic cattle breeding, and nowadays the usage of corn silage has increased in diet of sheep and goats as well. However, corn silage is above all the carbohydrate meal with low protein count, it has low aerobic stability and very often losses are great due to secondary fermentation.

In order to increase nitrogen maters (raw proteins) urea is being added (0.5-1.0%). With the same purpose corn is being grown as a joint crop along with soybean or horse bean or these annual legumes are being added while filling the silos. Solution for small aerobic stability of corn silage is in using hetero fermentative bacterial inoculants. These bacteria synthesize, besides milk acid, volatile acetic acid which is an excellent fungicide and stops the development of microorganisms.

Key words: *corn silage, additives, urea, inoculants.*

Introduction

The importance of corn as a crop species for animal and human nutrition is significantly increased with the spreading of ensiling conserving technology of the whole plant. That procedure is achieving more efficient use of agricultural land, higher yield of digestible dry matter, ruminant feeding with high moisture feedstuffs all through the year (independent of the time of vegetation), consistent composition of the ration as prerequisite for stabile milk production and others (Đorđević et al., 2005). However, corn silage has its shortcomings. First, this is high energy half-concentrated feedstuff, with low protein and mineral content. Although corn is easy to ensile, there is a big problem with its useful value, considering low aerobic stability (Đorđević et al., 2010). Because of all that corn is today used in many experiments that are conducted all over the world. In this paper we summarize the overview of most important foreign and domestic investigations in the technology of corn ensiling.

Selection of hybrids in order to increase nutritive value

Corn was selected for grain yield and resistance to diseases for a long period of time. It was considered that standard (grain) hybrids are also good for silage (Kamalak et al., 2003). The main goal in production of corn for silage is to obtain as much green mass (and dry matter) as possible, and high percentage of grains in the total mass. This is so because the

grains have the highest amount of nutrients. This is why it was important to take care about the optimal plant density in corn produced for silage. Modern maize hybrids have such habitus that allows them to be grown in more dense rows, which allows higher yield (Subedi et al., 2006). Increase of crop density in process of growing the silage maize is justified only from aspect of yield increase per acre, only if nutritional value of produced silage is not changed (Budakli et al., 2010).

In recent times the attention is given to the digestibility of the corn silage. Theoretically this problem can be solved with the use of fibrolytic enzymes and bacterial-enzyme inoculants. In some experiments it was confirmed that this kind of additives have complex influence on silage quality and nutritive value, and on animal performances (Đorđević et al., 1998). This is mostly concerning the alfalfa and other legume silages (Đorđević et al., 2006a). However, it has been proven that fibrolitic enzymes have effect mainly on easily digestible fiber fractions. Besides, for cellulase to work it is needed that pH is higher than 4.5. Moreover, the optimal combination of different cellulose solvents is needed to get the glucose. Because of all that results of usage of the fibrolitic enzymes during making of silage are more negative than positive (Kung and Muck, 1997). Therefore, because of the quoted problems nowadays in practice fibrolitic enzymes are added directly in to the meal and not during silaging. (Giraldo et al., 2008).

Especially interesting for silage is brow midrib hybrids because they have low content of lignin and therefore increased digestibility (Bal et al., 2000). In experiments with brown-midrib hybrids (bm3) the significantly lower level of lignin was determined and an increased *in vitro* digestibility of NDF and therefore higher milk production in cows (Barlow et al., 2012). However, these hybrids are not suitable for commercial production since they have low yield of grain and biomass for ensiling. For the last couple of years in scientific institutes which produce commercial hybrids of corn, digestibility has been intensively researched. Digestibility parameter for entire maize plant, with dry mater yield can contribute even bigger affirmation of the well known and new hybrids. Therefore, for example, Jovanović (2007) in his PhD thesis has proven that between four researched hybrids produced in Corn institute Zemun Polje are siginficant differences of digestibility, as well on productive characteristics of calfs that were fed with those hybrids.

In order to increase nutritive value of maize silage various other hybrids are produced such as high-oil (Weiss and Wyatt, 2000), waxy (Akay and Jackson, 2001) and others.

Procedures for increase of aerobic stability in silages

Corn is one of the plant species that are easily ensiled, due to its abundance of fermentable carbohydrates. This is why in its ensiling it is unnecessary (and even harmful) to use homofermentative bacterial inoculants to enhance lactic acid fermentation. (Đorđević et al., 2007). Because of the shorter duration of fermentation and high amount of sugars that remain unfermented, such silage is perfect substrate for the activity of aerobic microorganisms when the silo is opened. Low aerobic stability of corn silage is one of the largest problems with that feedstuff. It is occurring when silage is not used regularly and remains on the open air for longer periods of time. Several years ago it was confirmed that inoculation with Lactobacillus buchneri increases the aerobic stability in corn silages (Ranjit and Kung, 2000), which can be explained with the fact that it is a heterofermentative bacteria which is converting lactic acid do acetates. Lactic acid, as the main product of homofermentative processes of sugar fermentation in the ensiled mass, is a strong anti bacterial but weak fungicide agents. Contrary to that, acetic, propionic and butyric acid in corn silages are desirable to some degree. In the experiment performed by Hu et al. (2009) in was confirmed

that with the use of Lactobacillus buchneri inoculant better results are achieved with dryer material, which is important for practical application (table 1).

Table 1. Quality and erobic stability of corn silage (Hu et al., 2009)

Parameters	Dry matter %	Without Lactobacillus buchneri		With Lactobacillus buchneri	
		Without Lactobacillus plantarum	With Lactobacillus plantarum	Without Lactobacillus plantarum	With Lactobacillus plantarum
pH	33.1	3.54	3.56	3.65	3.66
	40.6	3.60	3.65	3.73	3.78
Lactic acid, %	33.1	3.39	4.12	1.97	2.60
	40.6	2.97	3.13	3.83	2.91
Acetic acid, %	33.1	0.84	1.02	1.33	2.23
	40.6	0.55	0.60	2.58	1.69
Aerobic stability, h	33.1	53	47	112	106
	40.6	49	53	236	300

The procedures to enhance nitrogen value (crude protein) in corn silages

Corn silage is considered as a half-concentrate feedstuff, with low concentration of crude proteins and minerals. The amount of nitrogen in corn silage can be increased with the addition of non protein nitrogen compounds, or with combination of corn with legumes.

The addition of nonprotein nitrogen compounds. The use of nonprotein nitrogen compounds in ruminant feeding has a long tradition. As a non protein source of nitrogen, in practice most significant is urea [$CO(NH_2)_2$], which averagely contains 42-46 % nitrogen, and 1kg of urea theoretically replaces around 2.8 kg of protein. Urea is being used as additive in concentrated part of the meal or during entire corn plant, wet corn grind or cob silage preparation. Because of its negative influence on fermentation today it is considered that better application of urea is in the concentrated part of the meal. Adding of urea has to be done with great caution regarding the amount of added urea, as if too much of urea is added or if it is not distributed evenly health problems will arise (Đorđević and Dinić, 2011). However, results of domestic research show that change in pH value of corn silage while using 0.5-1.0 % of urea have no significance on silage quality (Dinić et al., 2001; Đorđević et al., 2004a; 2006b). On the contrary to that, the significant increase in ammonia nitrogen and nitrogen soluble in ammonia, this can be a great problem in diet of rumnivorae. Therefore today urea is not being used as additive for silage in its pure form, but attached to some carrier which slows down its hydrolysis (Đorđević et al., 2006c).

Combination of corn with legumes. It is performed with the companion cropping techniques (with soya or faba beans), or by mixing with perennial legumes in the moment when silage is produced. The simultaneous production of corn and annual legumes is improving the high buffer capacity in legumes and providing better energy / protein ratio in ruminant diets (Đorđević et al., 2001; 2004b). With the production of companion crops there is a problem that legumes are in the shade of corn which is higher. This is why it is recommended to plant companion crops in alternating rows or ribbons. Dolijanović et al. (2006) found that corn and soybeans as companion crops had higher yields than when they were produced alone. Based on the experiment with 12 silage combinations Dinić et al. (1999) recommend that the amount of annual legume (particularly soybeans) should not be more than 50%. Đorđević et al. (2002) produced corn as a sole crop or in combination with Tetovac (white) beans. Corn was ensiled when its grains were in the milky-wax phase. The beans reached the top of corn plants and was 35.29% of the silo mass. The authors found higher yields of all nutrients when the two plants were produced as companion crops (table 2).

Table 2. Yield of green mass and nutritive matters, kg/ha (Đorđević et al., 2006b)

Parameters	Whole maize plant	Whole maize plant + bean	%, ±
Green mass	70764	82372	+16.40
Dry matter	18495.59	20998.27	+13.53
Crude protein	1731.04	2275.37	+31.45
Crude fiber	3240.74	4165.43	+28.53
Crude fat	656.65	747.96	+13.91
NFE	11711.32	12295.33	+4.99
Ash	1155.84	1514.19	+31.00

The combination of corn with perennial legumes (alfalfa) in the moment of ensiling also provides higher protein content in silage. Such method of ensiling is performed during the autumn, when corn and the last cut of alfalfa coincide. However, the different types of silo-combines are needed for those two crops. Also, the problem is how to mix those two plant species (Đorđević et al., 2002). It was experimentally confirmed that the best quality of produced silages is obtained when corn and alfalfa were included as 50:50% (Dinić et al., 1988).

Conclusion

Modern technologies of corn ensiling have the aim to obtain the starting material with as high nutritive value as possible, and the use of such techniques and additives to provide maximal preservation and increase in nutritive value of the silage. For corn silage today very important are additives based on heterofermentative lactic acid bacteria, which enable achieving of the high aerobic stability in the silage. That way many problems which exist in the practice of small farmers are avoided. The increase of nutritive value of corn silage can be obtained with companion crops (with annual legumes) oar with combination with perennial legumes (alfalfa) at the moment of ensiling. It this case it should be done in a way to prevent shade from corn in companion crops. This implies the use of right hybrid (corn) and cultivars (legume), and selection of proper seeding technique and agrotechnical procedures. Selection of corn hybrids with the increased digestibility and nutritive value is also providing significant results.

Acnowlegdements

The autors are grateful to the Ministry of Education and Science of the Republic of Serbia which financed this Project investigation within the No. III - 46012.

References

Akay, V., Jackson, J.A. (2001): Effects of Nutridense and waxy corn hybrids on the rumen fermentation, digestibility and lactational performance of dairy cows. Journal of Dairy Science, 84 (7): 1698-1706.

Bal, M.A., Shaver, R.D., Shinners, K.J., Coors, J.G., Lauer, J.G., Straub, R.J., Koegel, R.G. (2000): Stage of maturity, processing, and hybrid effect on ruminal in situ disappearance of whole–plant corn silage. Animal Feed Sience and Technology, 86: 83-94.

Barlow, J.S., Bernard, J.K., Mullis, N.A. (2012): Production response to corn silage produced from normal, brown midrib, or waxy corn hybrids. Journal of Dairy Science, 95 (8) : 4550-5.

Budakli, Çarpici, E., Çelik, N., Bayram, G. (2010): Yield and quality of forage maize as influenced by plant density and nitrogen rate. Turkish Journal of Field Crops, 15, 2: 128-132.

Dinić, B., Stošić, M., Koljajić, V. (1988): Uticaj različitog odnosa lucerke i kukuruzne biljke na kvalitet silaže. VI jugoslovenski simpozijum o krmnom bilju, 22-24.06.1988, Osijek. Zbornik radova, 525-534.

Dinić, B., Terzić, D., Đorđević, N., Lazarević, D. (1999): Effects of individual stubble crops share on silage. 9. Medzinarodne Sympozium: Konzervovanie objemovych krmiv. 6.-8. september 1999. Nitra. Proceedings, 146-147.

Dinić, B., Terzić, D., Radenović, Č., Jovanović, R. (2001): Oplemenjivanje kukuruzne silaže neproteinskim oblicima azota. Agroinovacije, 2: 179-183.

Dolijanović, Ž., Oljača, S., Kovačević, D., Jovanović, Ž. (2006): Različiti hibridi kukuruza u združenom usevu sa sojom. Biotehnologija u stočarstvu, 22 (spec. br.), 525-533.

Đorđević, N., Koljajić, V., Dinić, B. (1998): Korišćenje enzimskih dodataka kao stimulatora ili inhibitora aktivnosti mikroorganizama u silaži. Savremena poljoprivreda, 1-2: 149-154.

Đorđević, N., Grubić, G., Dinić, B. (2001): Effects of ensiling maize and soya green mass in various proportions. Symposium of livestock production with international participation. Macedonia, Struga, May, 23-25.2001. Jubilee year book, 213-217.

Đorđević, N., Koljajić, V., Dinić, B., Grubić, G. (2002): Oplemenjivanje kukuruzne silaže proteinima biljnog porekla. Biotehnologija u stočarstvu, 18, 5-6: 257-264.

Đorđević, N., Adamović, M., Grubić, G., Bočarov-Stančić, A. (2004a): Uticaj dodavanja uree i Min-A-Zel-a-plus na hemijski sastav i kvalitet silaža cele biljke kukuruza. Biotehnologija u stočarstvu, 20, 5-6: 187-194.

Đorđević, N., Grubić, G., Dinić, B., Negovanović, D. (2004b): Uticaj inokulacije na hemijski sastav i kvalitet silaža od soje i kukuruza. Biotehnologija u stočarstvu. 20, 1-2: 141 – 146.

Đorđević, N., Grubić, G., Radivojević, M., Stojanović, B., Adamović, O. (2005): Ishrana krava obrocima na bazi različitih vrsta silaže. XIX savetovanje agronoma, veterinara i tehnologa, 16-17.02.2005, Padinska Sakela. Zbornik naučnih radova, 11, 3-4: 65-73.

Đorđević, N., Grubić, G., Popović, Z., Dinić, B., Pandurević, T. (2006a): Uticaj bioloških i ugljenohidratnih dodataka na kvalitet silaže lucerke. XI savetovanje o biotehnologiji, Čačak, 3-4. mart 2006. Zbornik radova, 11 (II), 11-12: 479-485.

Đorđević, N., Grubić, G., Adamović, M., Stojanović, B., Simić, A. (2006b): Uticaj dodavanja Minazela Plus na kvalitet silaža kukuruza oplemenjenih neorganskim i organskim azotom. Biotehnologija u stočarstvu, 22 (poseban broj), 549-559.

Đorđević, N., Grubić, G., Adamović, M., Nježić, D., Nježić, A., Stojanović, B. (2006c): The influence of addition of zenural 70, urea and min-a-zel plus on chemical composition and quality of whole maize plant silage. Journal of Agricultural Sciences, 51, 1: 71-78.

Đorđević, N., Grubić, G., Adamović, M., Stojanović, B. (2007): The influence of inoculant and zeolite supplementation on quality of silages prepared from whole maize plant, lucerne and perennial ryegrass. I international congres: Food, Technology, Quality and Safety. Novi Sad, hotel Park, 13-15.XI. 2007. Proceedings, 51-56.

Đorđević, N., Grubić, G., Dinić, B., Lević, J., Stojanović, B., Božičković, A. (2010): Animal feed quality – past and present. XII international Symposium on Forage Crops of Republika of Serbia - Forage Crops Basis of the Sustainable Animal Husbandry Development. Biotechnology in Animal Husbandry, 26, book 1, 249-260.

Đorđević, N., Dinić, B. (2011): Proizvodnja smeša koncentrata za životinje. Institut za krmno bilje Kruševac.

Giraldo, L.A., Tejido, M.L., Ranilla, M.J., Ramos, S., Carro, M.D. (2008): Influence of direct-fed fibrolytic enzymes on diet digestibility and ruminal activity in sheep fed a grass hay-based diet. Journal of Animal Science, 86: 1617-1623.

Hu, W., Schmidt, R.J., McDonell, E.E., Klingerman, C.M., Kung, L. (2009): The effect of Lactobacillus buchneri 40788 or Lactobacillus plantarum MTD-1 on the fermentation and aerobic stability of corn silages ensiled at two dry matter contents. Journal of Dairy Science, 92 :3907–3914.

Jovanović, R. (2007): Svarljivost kao kriterijum nutritivne vrednosti silaže. Doktorska disertacija. Univerzitet u Beogradu, Poljoprivredni fakultet.

Kamalak, A., Erol, A., Gurbuz, Y., Ozay, O., Canbolat, O., Tumer, R. (2003): Evaluation of dry matter yield, chemical composition and in vitro dry matter digestibility of silage from different maize hibrids. Livestock Research for Rural development, 15, 11: 1-5.

Kung, L.Jr., Muck, R.E. (1997): Animal response to silage additives. Proc. from the Silage: Field to Feedbunk North American Conference. NRAES -99. Pp 200-210.

Ranjit, N.K., Kung, L. (2000): The effect of Lactobacillus buchnery, Lactobacillus plantarum, or chemical preservative on the fermentation and aerobic stability of corn silage. Journal of Dairy Science, 83: 526-535.

Subedi, K.D., Ma B.L., Smith D.L. (2006): Response of a leafy and non-leafy maize hybrid to population densities and fertilizer nitrogen levels. Crop Science, 46: 1860–1869.

Weiss, W.P., Wyatt, D.J. (2000): Effect of oil content and kernel processing of corne silage on digestibility and milk production by dairy cows. Journal of Dairy Science, 83: 351-358.