Biblid: 1821-4487 (2015) 19; 1; p 56-58
UDK: 631.363.1

Original Scientific Paper
Originalni naučni rad

THE QUALITY OF MAIZE PLANTS AND MAIZE GRAIN SILAGE ENSILED IN POLYETHYLENE FOIL

KVALITET SILAŽA OD BILJKE I VLAŽNOG ZRNA KUKURUZA SILIRANIH U POLIETILENSKOJ FOLIJI

Milan ADAMOVIĆ, Dragan MILIVOJČEVIĆ*, Čedomir ŽIVANOVIĆ*,*
*Aleksandra BOČAROV- STANČIĆ **, Predrag ŠORIĆ**
**AD „Dragan Marković", 11 500 Obrenovac, Kralja Petra I 27, Serbia*
***Institute for Science Application in Agriculture, 11000 Belgrade, Bul. Despota Stefana 69b, Serbia*
e-mail:milanadamovic2@gmail.com

ABSTRACT

Ensiling of maize plant and maize grain (FAO group 600) was carried out in polyethylene foils in company AD "Dragan Marković" in Obrenovac, Serbia. Diameter of the foils was 270 cm and length 65 m. Six weeks after ensiling in three polyethylene foils (1, 2 and 3) , the dry matter (DM) content of maize plant silage was optimal (30.89-32.39 %). Content of lactic acid was high (62.13 %-77.36 %), while the content of acetic acid varied from 19.27 % to 34.54 %. The pH values of these silages were similar (3.62-3.72). These silages were assessed according to DLG assessment system, and obtained between 45 and 49 points (Class I). The DM content of the fourth (4) foils maize plant silage (39.47 %) was higher than optimal and therefore affected its quality. In this silage, the content of lactic acid was lower (49.79 %), content of acetic acid increased (43.46 %), the pH value of this silage was higher (4.10) and it obtained 37 points (Class II). In two (1 and 2) polyethylene foils in which wet maize grain coarse meal was ensiled, the DM content of the silage was optimal (68.69 % and 74.38 %). The content of lactic acid was rather high (71.13 % and 72.91 %), the amount of acetic acid was much lower (27.09 % and 28.87 %), the pH values were 4.06 and 4.30 and these silages obtained 49 and 50 points (Class I). No losses were detected, by reason damage, in silages prepared in polyethylene foils.

Keywords: *Maize, silage, polyethylene foil.*

REZIME

Siliranje biljke i zrna kukuruza (FAO grupa 600) je obavljeno u polietilenskim folijama u preduzeću AD "Dragan Marković" Obrenovac, Srbija. Prečnik folija je iznosio 270 cm i dužina 65 m. Šest nedelja posle siliranja u tri folije (1; 2 i 3) sadžaj suve materije (SM) biljke kukuruza se kretao u optimalnim vrednostima (30,89-32,39%). Mlečna kiselina je bila dominantna (62,13-77,36%), sirćetna kiselina je varirala od 19,27% do 34,54%, a vrednosti pH su bile slične (3,62 - 3,729). Silaže su imale između 45 i 49 poena (I klasa). U četvrtoj foliji (4) silaža biljke kukurza imala je sadržaj SM (39,47%) veći od optimalnog što je uticalo na njen kvalitet. Sadržaj mlečne kiseline bio je manji (49,79%), a sirćetne (43,46%) povećan, dok je pH iznosio 4,10 i ocenjena je sa 37 poena (II klasa). U dve folije (1 i 2) u kojima je silirana vlažna prekrupa zrna kukuruza sadržaj SM se kretao u optimalnim vrednostima (68,69 odnosno 74,38%). Sadržaj mlečne kiseline bio je visok (71,13 odnosno 72,91%), količina sirćetne kiseline je bila znatno manja (27,09 odnosno 28,87%), a vrednost pH je iznosila 4,06 i 4,30 i ocenjene su sa 49 i 50 poena (I klasa). Gubici u silažama nisu primećeni. Obe vrste silaže imaju dobre organoleptičke osobine i goveda ih rado konzumiraju.

Ključne reči: *Kukuruz, silaža, polietilenska folija.*

INTRODUCTION

In the intensive livestock production there is a continuous need for implementation of new technological solutions that will lead to better use of reproductive and health performance of animals. Feed quality and safety are one of the most important factors in fulfilling such needs. When it comes to feed safety, and especially the safety of ensiled feed, storage conditions make an essential prerequisite for preserving its quality. Ensiling is a biotechnological method of preservation of wet forage and concentrated feed, which is based on a series of complex and intensive chemical, biochemical and microbiological processes. The most important product of these processes is lactic acid. It is produced by fermentation of water soluble carbohydrates, in the anaerobic environment, due to action of lactic bacteria. Lactic acid is a natural preservative and it acts bacteriostatic and bactericidal, preventing spoilage of silage and losses of nutrients *(Adamović et al., 2005).* On the other hand, organic acids produced during ensiling do not have adverse effects on moulds (they can grow between pH 3 and 8), so these microorganisms and their toxic metabolites (mycotoxins) can sometimes be found in ensiled feed. During the initial stages of ensiling, after oxygen depletion, strict aerobes (*Fusarium* species) are first to disappear, being followed by other, so-called field mycobiota (*Alternaria* and *Cladosporium* spp.). Dominant mycobiota become tolerant to oxygen deficiency, among which the most common are some *Mucorales* and *Penicillium* species, *Aspergillus fumigatus*, *Trichoderma viride*, *Geotrichum candidum, Paecilomyces variotii* and *Monascus ruber (Bočarov-Stančić et al., 2014)*. According to *Adamović et al. (2005)*, the most significant contaminants of whole maize plant and maize grain silages are fusariotoxins - zearalenone and type A trichothecenes (T - 2 toxin and DAS).

For successful ensiling and preserving the quality of silage, besides following the basic principles of ensiling (adequate dry matter content, plant phenophases, mass compressing, minimum sugar, material fragmentation, etc.), the most important factor is the quality of ensiling facilities (*Adamović et al.,1997; Dinić and Đorđević, 2005; Đorđević and Dinić 2007; Downing et al., 2008*).

The construction of silo facilities should protect silage and haylage from air inflow, thus providing quality fermentation and preventing subsequent fermentation. Moreover, these facilities have to protect feed from groundwater, accumulation and penetration of water sediments, and contamination with microorganisms from the environment *(Dinić and Đorđević, 2005).*

The aim of this study was to investigate ensiling of maize plant and maize grain in polyethylene foils, and to determine the quality of produced silages.

MATERIAL AND METHOD

Ensiling of a regularly sowed maize hybrid (FAO group 600) was carried out at company AD "Dragan Marković" in Obrenovac, Serbia. Harvesting of maize plants with dry matter content (DM) of 30-39 % and its chopping were carried out with a "Krone Big X 500" combine (Maschinenfabrik Bernard Krone GmbH, Germany), during 7 days, in the first half of September 2014. Ensiling 4,713 t of maize plant was performed in polyethylene foil (in the form of a tunnel) with a "Budissa Bag" press (Budissa Agroservice GmbH, Germany), at 4-5 bar pressure. The foil in which the biomass was filled under pressure had a diameter of 170 cm. It was 65 m long and 0.28 mm thick, with the capacity of 250 t of ensiled mass. The maize plant cut-outs were 0.7-1.0 cm long. Biomass harvested at different times and different biomass.

Ensiling of 2,065 t of wet maize grain coarse meal prepared from grains of regularly sowed (group FAO 600) was carried out, during 10 days, in the second half of November 2014, in the same type of a polyethylene foil, with the same press and at the same pressure as maize plants. Harvesting of grains (with 68-74 % DM) was done by a "Claas 560" combine, (Claas, Germany) with a built-in adapter for grain harvesting. Grinding of wet maize grains was conducted with two hammer mills, (Čakovec, Croatia) with a capacity of 5 t/h, and 15 t/h. The ground grain particles had a diameter characteristic for maize grain coarse meal (4 mm sieve).

Fig. 1. Press for filling polyethylene foil with fresh biomass

After filling, both types of silage, the foil was closed by folding its end and covering it with soil, thus preventing the ensiled material from air inflow. The foil was then perforated on the upper side, making a 3 cm hole in order to discharge residual air. After three days, the hole was closed by using a part of the foil as a hatch. Bacterial inoculant was not added in the silages both types.

The chemical composition and quality of both types of silages were determined six weeks after ensiling. The analysis of the chemical composition of the silages and the evaluation of their quality were conducted by "EKO-LAB" laboratory, (Belgrade), Serbia. The chemical composition (dry matter, crude ash, crude fat, crude fibre, crude protein, nitrogen free extract and pH) of the silages was determined according to the Regulations on sampling methods and the methods of physical, chemical and microbiological analysis of fodder *(Official Gazette of SFRY, 1987).*Organic acids (lactic, acetic and butyric) in the silages were determined according to the method titration and destilation and expressed in percenttage (%) according to total acids. Bound acids (acetic and butyric) was determined from the difference between total and free acids.

RESULTS AND DISCUSSION

Maize plant silage. Results of the analysis of chemical composition and quality of the maize plant silage are shown in Table 1. In the three foils (1, 2 and 3) the content of dry matter (DM) of maize plant silage was optimal and ranged from 30.89 % to to 39.47 %). Content of lactic acid ranged from 62.13 % to 77.36 %, while the content of total acetic acid was much lower (19.27 % to 34.54 %). The presence of free butyric acid was not detected whereas its presence in a bound form was only between 0.05 % and 4.65 %. The values of pH were very similar and varied from 3.62 to 3.72. These three silages obtained between 45 and 49 points and were classified as Class I according to DLG assessment system *(Đorđević and Dinić, 2007).*

The DM content of the fourth foils (4) maize plant silage (39.47 %) was higher than optimal, and therefore affected its quality. In this silage, the content of lactic acid was lower (49.79 %), total acetic acid increased (43.46 %), while the pH value was higher (4.10). This indicates that, due to a higher DM content, the compression of the biomass during ensiling was not sufficiently intensive, keeping more air in it and creating suitable conditions for the growth of acetic acid producing bacteria and therefore more extensive formation of acetic acid. The presence of free butyric acid in this silage was not detected, while its presence in bound form amounted to 7.20 %. Because of that, the fourth silage obtained 37 points and was classified as Class II.

Table 1. Chemical composition and quality of maize plant silage (air condition sample)

Parameter	1	2	3	4
Dry matter (%)	30.97	32.9	30.89	39.47
Crude ash (%)	1.15	1.09	1.22	1.73
Crude fat (%)	0.68	0.77	0.74	0.98
Crude fibre (%)	7.44	8.41	8.13	10.53
Crude protein (%)	2.06	2.07	2.16	2.95
NFE (%)	19.64	20.05	18.64	23.29
pH	3.62	3.63	3.72	4.10
Total lactic acid (%)	76.09	77.36	62.13	49.79
Free acetic acid (%)	17.64	19.90	31.03	39.61
Bound acetic acid, %	1.63	2.69	3.51	3.85
Free butyric acid (%)	ND	ND	ND	ND
Bound butyric acid (%)	4.64	0.05	3.33	7.20
Points	47	49	45	37
Class	I	I	I	II
NEL (MJ)	2.46	2.58	2.40	2.69

Legend: NFE - nitrogen free extract; NEL – net energy for lactation; ND - not detected.

After ensiling maize plant with a higher content of DM (50 %) in similar foils, Z*immer et al. (2009)* determined in the silage from one foil similar content of lactic acid (62.26 %) and acetic acid (37.74 %) at pH 4.17. In the silage from another foil (with 43 % DM), they found a significantly lower content of lactic acid (11.49 %), while acetic acid was dominant (88.51 %), with pH 4.02. These results indicate that possibly there was some negligence in the ensiling process in the second foil. The reason for such a ratio between lactic and acetic acid may be higher quantities of air remained in the second foil, which favoured the growth of acetic acid producing bacteria and production of tremendous amounts of acetic acid. It should be noted that these authors did not detected the presence of butyric acid in either of the two analysed silages.

Maize grain coarse meal silage. Results of the analysis of the chemical composition and quality of the maize grain silage are shown in Table 2. In the two ensiling foils (1 and 2) in which wet maize grain coarse meal was ensiled, the content of DM was optimal (68.69 % and 74.38 %). The content of lactic acid was rather high (71.13 % and 72.91 %), while the total amount of acetic acid was much lower (27.09 % and 28.87 %. Butyric acid was not detected, while pH values were 4.06 and 4.30. Wet maize grain coarse meal silages obtained 49 and 50 points and were classified as Class I.

Table 2. Chemical composition and quality of wet maize grain coarse meal silage (air condition sample)

Parameter	1	2
Dry matter (%)	74.38	68.69
Ash (%)	1.37	1.32
Fat (%)	2.85	2.65
Fibre (%)	1.54	0.93
Protein (%)	5.48	4.79
NFE (%)	6.14	5.00
pH	4.30	4.06
Total lactic acid (%)	72.91	71.13
Free acetic acid (%)	21.90	22.30
Tied acetic acid (%)	5.19	6.57
Free butyric acid (%)	ND	ND
Bound butyric acid (%)	ND	ND
Points	49	50
Class	I	I
NEL (MJ)	6.21	5.83

Legend: NFE - nitrogen free extract; NEL – net energy for lactation; ND – not detected.

No losses were detected in silages, by reason damage, prepared in polyethylene foils . Hence this mode of ensiling and storage has more advantages from a nutritional, economic and environmental point of view than using concrete horizontal bunker silos (the losses are up to 10-15 %). Both types of investigated silages had good organoleptic properties (colour and smell) and cattle liked to consume them.

In Jerusalem artichokes ensiled in a polyethylene foil of the same performance, *Adamović et al.* (2014) used the same press and recorded lactic acid content of 51.07 % and 57.01 %, as well as an increased total content of acetic acid (42.99 % and 48.93 %). The reason for such an increase in total amount of acetic acid probably lies in the specificity of the ensiling process in a foil. In this case, the compaction of the silage mass in the foil was probably of lower intensity, thus creating good conditions for the activity of lactic bacteria and therefore higher production of that acid. Similar conclusions about the importance of mass compaction and air elimination from silage were reported by *Đorđevic et al. (2012 and 2015).* Other authors (*Wagner et al.*, 2004; *Bhandri et al., 2008*; *McEniry et al., 2010; Yildiz et al., 2010)* also stated that the content of dry matter and crude fibre in silage mass, together with the length of the cuts, could significantly affect the quality and intensity of biomass compaction.

CONCLUSION

Ensiling of maize plant and wet maize grain coarse meal in a polyethylene foil resulted in high quality silages. The dominant is I clas with optimal values lactic acid and pH. The quality of silage maize plants with high content of DM (39.47 %) was smaller.The process ensiling is fast and it does not require mechanization for compaction. Moreover, the possibility of contaminating silage with external microorganisms is minimized as well as running out of juices and losing of nutrients. No losses were detected, by reason damage, in silages both types prepared in polyethylene foils. Foils can be placed in the most appropriate places in the yard or in the field. That makes a significant contribution to the environmental protection, which may give this method a preference over other ways of silage storage.

REFERENCES

Adamović, M. J., Bočarov-Stančić, A. S., Đorđević, N. Ž., Daković, A. S., Adamović, I. D. (2005). Mycotoxins in the silage – causes of creating, aftermath and protection from acting. Proc. Nat. Sci. Mat. Srp. N.Sad, 108, 51-57.

Adamović, M., Stoićević, Lj., Jovanović, R. (1997). Doprinos siliranja korišćenju organske materije i zaštiti okoline. Savetovanje Ekotehnologija u prehrambenoj industriji i biotehnologiji II, Zbornik radova, 233-242., Organizatori: Posl. Zajednica. "Vrenje" Beograd, i Tehn.-metalur.fak. Beograd, .V. Banja, Srbija,

Adamović, M., Milivojčević, D., Živanović, Č., Šorić, P., Vukosavljević, Z. (2014). Kvalitet i mogućnost korišćenja silaže čičoke u ishrani goveda. XIX Savetovanje o biotehnologiji, Agronomski fakultet, Čačak, Srbija, 359-364.

Bhandari, S. K., Ominski, S., Li, K. H., Wittenberg, K. M., Plaizier, J. C. (2008). Effects of the chop lengths of alfalfa silage and oat silage on feed intake, milk production, feeding behavior, and rumen fermentation of dairy cows. Journal of Dairy Science, 91, 1942–1958.

Bočarov-Stančić, A., Stanković, S., Janković, S., Adamović, M., Novaković, Ž., Kuzevski, J. (2014). Presence of mycobiota and mycotoxins in silage. XVI Inter. Symp. Feed Technology, Inst. of Food Technology, N. Sad, Serbia, 1-6.

Dinić B., Đorđević, N. (2005). Pripremanje i korišćenje silaže. Monografija. Izdavač Institut za istraživanje u poljoprivredi Srbija. Beograd.

Downing, T., W., Buyserie, A., Gamroth, M., French, P. (2008). Effect of Water Soluble Carbohydrates on Fermentation Characteristics of Ensiled Perennial Ryegrass. The Professional Animal Scientist, 24, 35-39.

Đorđević, N., Dinić, B., Grubić, G., Stojanović. B., Božičković, A., Dubljević, R., Mitrović, D. (2015). Značaj stepena sabijenosti kao faktora kvaliteta silaže. XXIX Savetovanje agronoma, veterinara, tehnologa i agroekonomista, Organizator Institut PKB Agroekonomik, Zbornik naučnih radova, br. 3, 73-79, Beograd.

Đorđević, N., Dinić, B. (2007). Hrana za životinje. Cenzone tech-Europe d.o.o. Aranđelovac, Srbija.

Đorđević, N., Grubić, G., Dinić, B., Stojanović, B., Radivojević, M., Božičković, A. (2012). Uticaj fenofaze, otkosa i stepena provenulosti na parametre hemijskog sastava, proteolize i kvaliteta silaže lucerke. XXVI. Savetovanje agronoma, veterinara, tehnologa i agroekonomista. Organizator Institut PKB Agroekonomik, Zbornik naučnih radova, 18 (3-4), 41-47, Beograd

McEniry, J., O'Kiely, P. O., Clipson, N. J. W., Forristal, P. D., Doyle, E. M. (2010). Assessing the impact of various ensilage factors on the fermentation of grass silage using conventional culture and bacterial community analysis techniques. Journal of Applied Microbiology, 108, 1584-1593.

Regulations on sampling methods and the methods of physical, chemical and microbiological analysis of fodder (1987). Official Gazette of SFRY, No 15/87.

Wagner,A., Leurs, K., Buscher, W. (2004). Maize silage-The influence of crop lenght on compactibility, ensiling and secondary fermentation. Landtech, 4, 218-219.

Yildiz, C., Öztürk, S., Erkmen, Y. (2010). The effects of harvest period, chopping lenght and compaction pressure on forage quality of sorghum (*Sorghum bicolor* L.) silage. Journal of Agricultural Machinery Science, 6 (3), 191-195.

Zimmer, R., Pichler, S., Košutić, S., Jelošek, D. (2009). Uzgoj, košnja i uskladištenje silažnog kukuruza u AG-BAG fleksibilno crijevo.

https://bib.irb.hr/datoteka/403554.53_Zimmer_Opatija_09_.doc

Received: 24.02.2015. Accepted: 24.03.2015.