

# THE EFFECT OF DIGESTIBILITY OF MAIZE HYBRIDS ON PRODUCTION PERFORMANCE OF FATTENING YOUNG CATTLE

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**Abstract:** The effects of use of silage made from 4 maize hybrids (A, B, C and) of different dry matter digestibility (DM) on production performance of fattening cattle were investigated. Trial was carried plan on 60 male cattle of Holstein-Friesian Black and White breed, divided into 4 groups of 15 heads of each. Nutrition trial lasted 84 days. DM digestibility of maize hybrids used in this nutrition trial established *in vitro* was 58.38; 67.57; 60.74 and 61.91%, realized average daily gains of cattle were 813; 884; 816 and 836 grams and established differences were significant (A,C  $P<0.05$  and A,B  $P<0.01$ ). Silage digestibility established by indirect method with  $Cr_2O_3$  was 65.64; 76.10; 70.90 and 72.78 % and differences were also significant (A,B  $P<0.01$  and A,C  $P<0.05$ ). Differences in *in vitro* digestibility of dry matter of maize hybrids were in the amount of 9.2 percent points (67,57:58,38%) resulted in greater body mass of young cattle in average by 6,73 kg per head, i.e. higher daily gain of young cattle by 71 grams or 8,7%. Results of these researches indicated that dry matter digestibility of maize hybrids is extremely significant parameter of nutritive value.

**Key words:** digestibility, maize hybrids, silage, fattening cattle

## Introduction

Adequate nutrition of animals includes knowledge of the characteristics of used feeds, their nutritive value, nutritional needs, possibility for consumption and utilization of food. Primary task of nutritionists is to adequately investigate and evaluate the quality of fodder livestock food used in diets for livestock. Of course, trials carried out on animals are most reliable way to determine the nutritive value of certain feed.

Assessment of new maize hybrids in regard to their value is based mainly on grain yield. On the other hand, not enough attention is directed towards the assessment of

maize hybrids as forage plants, i.e. criteria which are of importance when whole plant is utilized in nutrition of ruminants. Validation of maize hybrids based on grain yield is mainly based on the assumption that hybrids which realize the highest grain production are at the same time the most suitable for production of whole plant silage. But, new scientific researches are indicating that other factors should be taken into consideration which have considerable impact on efficiency of utilization of the maize plant in the form of silage in livestock nutrition. Knowledge of chemical structure alone is often insufficient parameter for evaluation of nutritive value of feeds since for more precise assessment it is necessary to be aware of the level of their utilization by animal organism. Investigation of digestibility as a criterion of nutritive value in the evaluation of maize hybrids as silage plants is very important parameter in selection of hybrids.

Although maize is regarded as most important silage plant, not enough attention was dedicated to studies aiming to defining of criteria which would serve as basis in creation of new hybrids and evaluation of their quality as silage plants.

## **Digestibility as a method for evaluation of the nutritive value of maize plant**

Based on data on chemical composition of feeds it is not possible to make accurate conclusion about its nutritive value since some nutritive substances are incompletely or very moderately utilized in digestion organs of the animal. Although for evaluation of nutritive value of certain feed different criteria are used – digestibility is certainly the most important parameter which precisely indicates the difference between potential and true/actual nutritive value of a feed.

Digestibility is most appropriately determined in digestibility trials used for determination of the amount of nutritive substances excreted by faeces. Carrying out of such trials most often includes nutrition of trial animals with previously determined amount of feed whose digestibility is investigated. Digestibility of fodder feeds is closely related to morphological structure of the plants. Standard (Weende) procedure for chemical analysis of fibres, known under the term of crude cellulose/fibre, developed by *Henneberg and Stohmann (1860)* doesn't express in sufficient precision the share of fibre in feeds since one part of hemicellulose and lignin is lost during the analysis. Therefore, more up to date procedure was developed for determination of fibre components using so called detergent method developed by *Van Soest (1963)* and *Van Soest and Wine, (1967)*. According to this method, dry matter in fodder feeds, based on its availability to animals, is made by two fractions. First fraction represents the cell content and it consists of carbon hydrates, lipids and proteins, and it is mainly available to animals. The second fraction is made of cell walls and it defines total fibres, and in regard to availability to animals it shows significant hesitations/uncertainties

because of the presence of mutual relation between lignin, hemicellulose and cellulose.

Maize plant is carbon hydrate feed which consists primarily of structural carbon hydrates, but has a high share of non-structural carbon hydrates which makes it feed of high quality in nutrition of ruminants. Investigation of the effect of certain chemical components on nutritive value showed that structural carbon hydrates or content of cell walls have negative effect on digestibility of this feed. In spite of the fact that two basic structural carbon hydrates of the cell walls, cellulose and hemicellulose, in theory are totally digestible, digestibility of maize plant, i.e. silage practically is lowered by presence of lignin. It is considered that lignin represents a physical barrier which impedes the microbial fibre degradation in fore-stomachs of ruminants. Namely, plant cell walls provide structure, firmness as well as protection for plants from stresses of the environment. Of several factors which can influence the fibre digestibility, *Jung and Deetz (1993)* and *Jung and Buxton (1994)* consider the lignin content to be of the greatest influence and that lignin disrupts the microbial fibre degradation as a physical barrier. They especially point out the importance of bonds of lignin with polysaccharides through ferulate bridges as additional factor which prevents digestibility of cell walls.

Modern selection of maize hybrids includes creation of hybrids of greater resistance to flattening whereas digestibility is not especially considered. *Jung and Alen (1995)* and *Buhton et al. (1996)* point out that quality and digestibility of maize silage can be increased by selection/breeding through reducing of fibre or increasing the scope of their digestibility. These authors point out that in this way the consumption of dry matter can be increased as well as animals' production performance.

Presence of significant differences in digestibility of different maize hybrids was also confirmed in their research by *Bratzler et al. (1965)*, *Deinum and Dirven (1971)*, *Deinum (1987)* and *Pejić et al. (1988)*.

*Pejić (1988)* when summarizing the results of several year research of large number of maize hybrids from different FAO groups of maturation, concluded that genetic basis has essential impact on quality of maize plant for silage. This author stated that yield and its structure, digestibility of certain morphological plant parts and reaction of hybrids to ecological cultivation conditions are the most important criteria which have to be considered in evaluation of maize hybrids as silage plants. This author stated that in selection of hybrids for sowing mentioned facts should be taken into consideration, and that growing of those maize hybrids is recommended which in specific region can reach full wax maturation, i.e. stage which is optimal for ensiling.

*Bekrić et al. (2000)* stated two strategies of livestock food producers in regard to selection of maize hybrid for ensiling. First: that the hybrid is good for grain as well as for silage, and the second: that there is significant difference in digestibility of cell walls between plants of different hybrids and accordingly in

digestibility. Trials of digestibility of organic matter carried out on 12 locations in Europe showed great variability of this trait between different hybrids and it was from 69,7% to 81,4%. Also, it was established that digestibility has low correlation with share of maize ear in the mass and yield of dry matter, but high correlation with structure of cell walls.

*Jovanović et al. (2002)* state that in selection of maize hybrid for silage it is necessary to consider following indicators: yield of DM of whole plant in t/ha, share of ears in DM of yield, fibre content in acid detergent fibre (ADF) as well as *in vitro* digestibility in rumen fluid according to *Tilley and Terr (1963)*. These authors emphasize the significance of parameters which influence the nutritive value of maize hybrids as well as selection of adequate hybrids for certain region.

Modern selection/breeding of hybrids mainly starts with identification of the group of hybrids which are adapted to soil in regard to maturation period, standardizing in regard to diseases and resistance to insects and tolerance to drought. Numerous researches showed that yield of grain is genetic indicator of the yield of whole plant, so hybrids with higher grain yield also give higher silage yield. However, within the group with higher yield of grain some differences can be demonstrated in regard to whole plant yield and digestibility of dry matter, supporting the need for more data on these parameters.

## Materials and Methods

For the purpose of testing of the effect of maize hybrids for silage of different digestibility on production performance of animals in production conditions, a trial was carried out on young cattle. Four maize hybrids of different DM digestibility were tested (A, B, C, D) from which adequate quantities of whole plant silage was prepared in silo trench according to usual technology and used in nutrition of young cattle. For all investigated whole plant maize silage quality was determined according to DLG classification. In all investigated maize hybrids, using *Van Soest (1967)* detergent method following fractions were established: neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin in acid detergent (ADL) as well as *In vitro* digestibility of dry matter of whole maize plant at the moment of ensiling using *in vitro* method by *Tilley and Terry (1963)*. Rumen liquid necessary for *in vitro* method of digestibility analysis was taken from cows using rumen probe (patent of the Veterinary Scientific Institute from Novi Sad). The research was done in the maize Research Institute in Zemun Polje.

Nutrition trial was done in the period March – July, according to scheme of completely random plan on 60 young cattle of Holstein-Friesian Black and White breed on the farm Kovilovo which is part of the system of Agricultural Corporation Belgrade PKB. Trial animals were divided into 4 groups of 15 male young cattle of average body mass of 247 kg. Maize silage and concentrate mixtures were given

two times. Nutrition was individual and remaining food that was not consumed was weighed daily.

Nutrition trial lasted 84 days and consisted of two phases. In the first phase in duration of 53 days, animals were fed diet consisting of maize silage and concentrates mixture in dry matter ratio of 60:40%. In the second trial phase in duration of 31 days, young cattle were fed only maize silage. For the purpose of comparison of results obtained for digestibility using *in vitro* method of *Tilley and Terry (1963)* at the end of trial on 5 most uniform animals on each treatment indirect digestibility was done where as indicator chrome trioxide measured on paper bags of 10 grams each was used which was directly introduced through oesophagus of animals twice a day (at 7 and 19 h). Content of chrome in faeces of trial animals was analyzed in the laboratory of the Institute for Animal Husbandry in Belgrade.

Animals were housed in the facility of the semi-open type during the trial, in the tie system of housing (Grabner chain). During trial the body mass of young cattle and consumption of food were monitored.

## Results and Discussion

Chemical composition, quality and digestibility of investigated hybrids are presented in Table 1.

**Table 1. Chemical composition, composition of crude fibre fractions and digestibility of investigated maize hybrids**

Indicator	Maize hybrids			
	A	B	C	D
DSM,%	32.33	32.56	31.34	31.76
Ashes,%	1.39	1.77	1.70	1.50
Cellulose,%	7.34	6.40	6.95	6.74
Fat,%	0.90	1.03	0.91	0.99
Protein,%	1.52	1.98	1.72	2.08
NFE,%	21.18	21.38	20.06	20.29
ADF,% of DM	26.43	22.92	25.53	24.9
NDF,% of DM	50.62	41.94	48.75	45.15
ADL, % of DM	3.73	3.25	3.34	3.63
Points according to DLG classification	45	45	44	47
Silage class according to DLG	I	I	I	I
DM digestibility In vitro,%	58.38 <sup>b</sup>	67.57 <sup>a</sup>	60.74 <sup>b</sup>	61.91 <sup>b</sup>
DM digestibility In vivo,%	65.64 <sup>c</sup>	76.10 <sup>a</sup>	70.90 <sup>b</sup>	72.78

a,b(P< 0.01)ac (P< 0.05)

Maize silages on all treatments had relatively equal composition of major nutritive substances. Content of DM of 32,33; 32,56; 31,34 and 31,76% indicates

that all maize hybrids used in nutrition trial were harvested during optimal stage for ensiling. Timely harvesting of maize plants, with adequate technology of ensiling surely contributed to obtaining of I class silage. Established values of crude fibre ADF, NDF and ADL show that although maize hybrids were harvested in the same physiological stage of maturation there are some differences between them.

Lignin content which directly reflects on digestibility according to treatments A, B, C, D was 3,73; 3,25; 3,34 and 3,63 % respectively.

These differences in structure of plant cells i.e. fractions of crud fibred most probably caused different digestibility of maize hybrids.

*In vitro* digestibility of investigated hybrids was established by method according to *Tilley and Terry (1963)* was in direct dependence to content of major constituents of cell and cell wall content. Namely, established values according to order of treatments A:B:C and D of 58,37; 67,57; 60,74 and 61,91% most noticeably showed that there were differences between maize hybrids in regard to digestibility. Expressed differences were statistically significant ( $p < 0.05$ ). The highest coefficient of DM digestibility (67,52%) was determined in hybrid B which at the same time had the lowest values of the content of ADF, NDF and lignin and the lowest in hybrid A (58,37% ). Maize hybrids C and D had rather similar composition of major constituents such as digestibility *in vitro* 60,73 and 61,91%. Obtained results in regard to content of ADF, NDF and ADL and digestibility were fully in accordance with those obtained by *Hunt et al. (1993)*. Namely, in investigation of nutritive characteristics of maize plant of two Pioneer hybrids (3377 and 3389) these authors established the lower content of ADF of 26,3:30,0 NDF of 42,7: 48,1 and lignin 3,4:3,8 caused lower digestibility compared to by 6,1 percents higher digestibility of DM *in situ* (60,7; 54,6) and 4,7 percent *in vitro* (71,8; 67,1%).

Results for digestibility obtained by indirect method greatly are in accordance to results obtained by *in vitro* method of *Tilley and Terry (1963)*, as well as realized production results of young cattle. Same as *in vitro* investigations, the highest digestibility coefficient was obtained in case of silage B - 76,10 %, and the lowest value for this parameter was established for hybrid A - 65,64 %. Established differences in digestibility between investigated hybrids were highly significant ( $P < 0,01$ ). It is noticeable that obtained values compared to results obtained in laboratory conditions in the method by *Tilley and Terry (1963)* were slightly higher although the trend remained the same. Also, differences according to the order of treatments A;B;C;D the values *in vitro* 58,37; 67,57; 60,73; 61,91 are compared in relation to indirect method of digestibility 65,64; 76,10; 70,98; 72,78 obtained higher values for indirect method were 7,27; 8,53; 10,16; 10,87 respectively.

Different digestibility of maize hybrids used in the trial cause differences in production performance of trial animals which are presented in Table 2. Namely, higher digestibility of maize hybrids which primarily includes better utilization of

nutritious substances in digestive organs of young cattle resulted in better production performance – increase of gain.

**Table 2. Body mass and gain of young cattle during 84 day trial**

Treatment	Initial BM , kg	Final BM, kg	Total gain kg	Average daily gain, gr
A	247.466	315.333 <sup>c</sup>	68.333 <sup>c</sup>	813 <sup>b</sup>
B	247.800	322.066 <sup>a</sup>	74.266 <sup>a</sup>	884 <sup>a</sup>
C	247.200	315.733 <sup>c</sup>	68.533 <sup>c</sup>	816 <sup>b</sup>
D	246.600	316.800	70.200	836

a,b(P< 0.01).ac (P< 0.05)

Considering that young cattle of dairy type were used as well as average diet composition which consisted mainly of maize silage, this gain can be considered as satisfactory. Obtained values in regard to realized average gains completely are in accordance to determined values for DM digestibility. In regard to entire nutrition trial of 84 days, the best production results were achieved by young cattle on treatment B using the diet with hybrid for which the highest DM digestibility *in vitro* of 67,57% was established. Total average yield for entire trial period on this treatment was 74,27 kg. The lowest yield was registered I animals on treatment A, which received silage made of maize hybrid with the lowest digestibility coefficient 58,37 % where the total yield per head of cattle determined was 68,33 kg. On the other hand, similar values regarding digestibility in hybrids A and C 58,37 and 60,74% gave similar results in regard to yield 68,33 and 68,53 kg.

The highest daily gain (884 grams) was realized on treatment B compared to diet where the maize hybrid of highest digestibility 67,57 *in vitro* i.e. 76,1% by indirect method with chrome trioxide was used. At the same time, young cattle on treatment A which received silage made from the hybrid of the lowest digestibility (58,38 *in vitro* i.e. 65,64% *in vivo*) realized the lowest daily gain of 813 grams per head.

Obtained results are completely in accordance to those obtained by *Hunt et al. (1993)* in their researches. In investigations of the characteristics of maize plant of two Pioneer hybrids (3377 and 3389 ) these authors established that silage from hybrid 3377 which had by 6,1 percents higher digestibility of DM *in situ* (60,7; 54,6) and by 4,7 percents *In vitro* (71,8; 67,1) resulted in by 6,9 % higher gain of young cattle 1,08; 1,01kg. Demonstrated differences were statistically significant (P<0,05)

Importance of the study of the digestibility of hybrids from the aspect of livestock nutrition is also emphasized by *Cors et al. (1994)*. He stated example of two Pioneer hybrids, 3377 and 3389, which had similar ratio of dry matter yield and share of grain in plant mass, but different digestibility. Heifers which consumed silage of the higher digestibility realized by 8% higher gain with 10% lower food per unit of gain, compared to heifers which consumed silage of lower

digestibility which in economical sense amounted to profit of 193\$ per hectare for silage of higher digestibility.

Production performance, i.e. gain of body mass of young cattle during nutrition trial illustrated in the best way the importance of maize silage digestibility as a nutritive parameter. Results obtained in this research as well as results obtained by other authors show that DM digestibility of maize hybrids is considered as major factor which must be taken into consideration in evaluation of the hybrids used for preparation of silage.

## Conclusion

Based on carried out research – testing of 4 maize hybrids (A, B, C and D) in optimal stage for ensiling in regard to fibre content and impact on production performance of fattening young cattle, the following can be concluded:

- Differences were established between maize hybrids used in the nutrition trial in regard to DM digestibility. Digestibility of DM of investigated maize hybrids determined *in vitro* by method of *Tilley and Terry (1963)* was 58.38; 67.57; 60.74 and 61.91%. Expressed differences were statistically highly significant ( $P < 0.01$ ).
- Digestibility of silages used in nutrition trial established by indirect method with  $\text{Cr}_2\text{O}_3$  was 65.64; 76.10; 70.90 and 72.78%, and differences between hybrids were also highly significant (A,B  $P < 0.01$  and A,C  $P < 0.05$ ). Same as in indirect method, the highest digestibility was established for hybrid B (76.10%) and the lowest for hybrid A (65.64%)
- Established values for content of crude fibre fractions (NDF, ADF and ADL) differed significantly between hybrids and are close related to digestibility.
- Differences in digestibility of investigated maize hybrids according to order of treatments A;B;C and D caused differences in production results recorded for animals in trial. According to same order of treatments, average daily gain of young cattle was 813; 884;815 and 835 grams. Expressed differences were significant (A,B  $P < 0.01$  and A,C  $P < 0.05$ ).
- Differences in *in vitro* digestibility of DM of whole plants between maize hybrids A and B of 9,2% (67.57:58,38%) during 84 day trial resulted in higher yield of 6,73 kg per head i.e. higher average daily gain of young cattle by 71 grams or 8,7 %.

Results of this research unambiguously show that digestibility of maize hybrids is very important parameter of nutritive value. Differences in digestibility which are directly correlated to genetic basis of hybrid to great extent influence nutritive value of maize plant, i.e. silage and by this also production results of animals. This important parameter surely has to be considered when choosing



hybrid for silage as well as in selection/breeding programs when new lines and hybrids of maize are created for this purpose.

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## Uticaj svarljivosti hibrida kukuruza na proizvodne rezultate tovne junadi

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## Rezime

Ispitivani su efekti korišćenja silaža 4 hibrida kukuruza (A, B, C i D) različite svarljivosti suve materije (SM) na proizvodne rezultate tovne junadi. Ogled je izveden po šemi potpuno slučajnog plana na 60 muških junadi holštajn frizijske crno – bele rase, raspoređene u 4 grupe od po 15 grla u svakoj. Ishranbeni ogled trajao je 84 dana .

Svarljivost SM hibrida kukuruza korišćenih u ishranbenom ogledu utvrđena *in vitro* metodom iznosila je 58.38; 67.57; 60,74 i 61.91% ostvareni su prosečni dnevni prirasti junadi od 813; 884; 816 i 836 grama a ispoljene razlike bile su signifikantne (A,C P<0.05 i A, B P<0.01) Svarljivost silaža utvrđena indirektnom metodom sa Cr<sub>2</sub>O<sub>3</sub> iznosila je 65.64; 76.10; 70.90 i 72.78 % a razlike su takođe bile signifikantne (A, B P<0.01 i A,C P<0.05). Razlike u *in vitro* svarljivosti suve materije od hibrida kukuruza od 9.2 procentna poena (67,57:58,37%) u toku 84 dana ogleda rezultirale su u većoj telesnoj masi junadi u proseku za 6,73 kg po grlu, odnosno većim dnevnim prirastom junadi od 71 gram ili 8,7%.

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