PRODUCTION RESULTS OF DAIRY COWS FED GRASS AND ALFALFA SILAGE WITH A DIFFERENT DEGREE OF WILTING

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Summary. The objective of this study was to determine the effect of grass and alfalfa silage made with roll balers from wilted raw material on milk yield, milk composition and feed utilization in dairy cows fed high-concentrate diets. Experimental silage was produced from first-cut grass-alfalfa mixtures wilted for 6 or 24 h. One hundred thirty Holstein-Friesian cows were divided into two equal feeding groups: Group 1 – silage made from green fodder wilted for 6 h, Group 2 – silage made from green fodder wilted for 24 h. Experimental silage was offered *ad libitum* during 60-day period, together with corn silage (15 kg/d) and concentrated feed (above milk yield of 16 kg, in the amount of 0.5 kg/kg milk). The different degree of green forage wilting prior to ensilage had no effect on average milk yield, ECM yield, the protein content of milk, or the average daily yield of milk protein and milk fat per cow. Only the fat content of milk was statistically higher ($p<0.05$) in cows fed silage with a lower degree of wilting (Group 2) compared to Group 1. Milk from cows given silage with a higher moisture content (Group 1) had a higher concentration of urea ($p<0.01$). There were no differences between the two feeding groups with respect to the utilization of dry matter, energy and protein. Starting from day 200 of lactation, milk production was higher ($p<0.05$) in cows fed silage with a higher degree of wilting (Group 2). However, due to a lower fat content of milk ($p<0.05$) these differences were found to be statistically non-significant when converted to ECM.

Key words: wilting, silage bales, dairy cows.

MELŽIAMŲ KARVIŲ PRODUKTYVUMAS IR PIENO SUDĖTIS ŠERIANT JAS SILOSU, PAGAMINTU IŠ SKIRTINGĄ LAIKĄ VYTINTOS VARPINIŲ IR ANKŠTINIŲ ŽOLĖS MIŠINIO

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Santrauka. Šio tyrimo tikslas buvo nustatyti nevienodai pavytinto varpinių ir ankštinių (mėlynžiedė liucerna, motiejukai ir svidrė) žolių mišinio siloso, pagaminto ritiniais, įtaką melžiamų karvių pieno primilžiams, pieno sudėčiai ir pašaro panaudojimui, kai šeriama koncentruotu šėrimo tipu. Silosas buvo pagamintas iš pirmosios pjūties varpinių žolių ir mėlynžiedės liucernos mišinio, vytinto 6 ir 24 valandas. 130 Holšteino fryzų veislės karvių buvo suskirstytos į dvi grupes: I grupė buvo šeriama silosu, pagamintu iš 6 val. vytintos silosuojamos žaliavos, o II rupė – silosu, pagamintu iš 24 val. vytintos silosuojamos žaliavos. Vytinto siloso buvo duodama 60 dienų iki soties kartu su 15 kg javų siloso ir 0,5 kg kilogramui pieno koncentruotojo pašaro (primilžis daugiau nei 16 kg). Skirtingas silosuojamos masės vytinimo laikas neturėjo poveikio vidutiniam primilžiui, ECM (energiškai koreguotas pienas) išeigai, baltymų kiekiui ir vidutiniam paros pieno baltymų ir pieno riebalų kiekiui. Karvių, šertų silosu iš trumpesnį laiką vytintos žolės, piene riebalų buvo daugiau ($p<0,05$). Karvių, šertų drėgnesniu silosu, piene buvo didesnė šlapalo koncentracija ($p<0,01$). Raciono sausųjų medžiagų, energijos ir proteinų sąnaudos abiejų karvių grupių nesiskyrė. Nuo 200 laktacijos dienos karvės, šertos ilgesnį laiką vytintu silosu, davė daugiau pieno ($p<0,05$), tačiau dėl mažesnio pieno riebumo ($p<0,05$) koreguoto pieno (ECM) kiekis tarp grupių iš esmės nesiskyrė.

Raktažodžiai: vytintas silosas, siloso ritiniai, meldžiamos karvės.

Introduction. The quality of silage made from high-protein crops is affected by a variety of factors. Therefore, silage production technologies must be continuously improved and silage quality needs to be monitored in order to meet the nutrient requirements of high-producing animals, and to incorporate silage-based diets into modern cattle feeding system. Studies on the quality of round bale silage focus primarily on the impact of particular stages of the technological process on fermentation and storage stability (Monkevičienė, Sederevičius 1998; Nowak, Šařec 2001; Monkevičienė et al. 2001; Lingvall 2002). The quality of round bale silage is dependent on bale density and air-tightness (Nowak, Šařec 2001, Lingvall 2002, Rhein et al. 2005). Bale density is determined by the physical properties of the ensiled material (stem thickness and length, moisture content, elasticity), which in turn depend on crop species, wilting degree and growth stage (Nowak, Šařec 2001). Bale density not only considerably affects fermentation and storage stability (Heikkila et al. 2002, Davies et al. 1998), but also permits to reduce the number of bales produced per unit area of crop and the quantity of wrapping foil used, as well as the costs of transport and storage (Lingvall 2002).

Roughage intake may be estimated based on the results obtained for single-component diets or mixed diets (Allen 1996). Silage intake is related not only to cell wall content and digestibility (Dawson et al. 1999, Wright et al. 2000), but also to the impact of fermentation products and modification of carbohydrate and nitrogen fractions (Huhtanen et al. 2002; Laugalis et al. 2004). Numerous feeding trials conducted under various conditions provided a basis for analyzing the relationships between the degree of grass wilting before ensiling and silage intake by cattle or the production results of dairy cows (Dawson et al. 1999, Wright et al. 2000). The correlations between the proximate chemical composition of silage, fermentation profile and silage intake (Steen et al. 1998), as well as between the levels of particular fermentation products in silage and milk yield, the yield and content of milk fat and milk protein (Huhtanen et al. 2003) have also been determined.

The ensiling of high-protein green forage affects also nitrogen utilization and excretion in ruminants (Jones 2000, Frank et al. 2002, Slottner, Bertilsson 2006). Broderick at al. (2001) reported that red clover or alfalfa silage fed to cattle are a more efficient source of nitrogen for bacterial protein synthesis than grass silage. The degree of proteolysis in silage is negatively correlated with the concentrations of dry matter and WSC, and positively correlated with the N–NH_3 content of silage (Han et al. 2006). Protein degradation in silage may be limited by material pre-wilting, by the addition of organic acids or by the domination of homofermentative bacteria (Winters et al. 2001). The end products of protein degradation during ensilage are free amino acids, ammonia and biogenic amines, which leads to qualitative changes in the amino acid composition of silage protein (Jones 2000, Givens, Rulquin 2004). Steidlová and Kalač (2004) observed a negative effect of biogenic amines on silage intake. Slottner and Bertilsson (2006) found that an increase in dry matter concentration, as well as biological and chemical additives inhibit proteolysis regardless of the method of green forage harvest. A positive influence of pre-wilting on the level and degradability of protein was demonstrated by Brzóska et al. (1999).

Due to the fact that round bale silage made from high-protein crops is commonly fed to cattle on dairy farms, more and more research studies address silage quality issues. Moreover, a question arises whether the degree of wilting before ensiling and the level of dry matter in silage may affect the productivity of cows fed high-concentrate diets. Thus, the objective of the present study was to determine the effect of grass and alfalfa silage made with roll balers from wilted raw material on milk yield, milk composition and feed utilization in dairy cows fed high-concentrate diets.

Materials and Methods. The study was carried out on a dairy farm located in north-eastern Poland. Experimental silage was produced from first-cut grass-alfalfa mixtures (alfalfa 35%, timothy grass 30%, Italian ryegrass 15%, perennial ryegrass 20%) in the second year of utilization, following two-phase harvesting. Grassland was mown at the budding stage of alfalfa and at the ear formation stage of grass, with a drum mower equipped with a mulching attachment. Green forage was wilted for 6 or 24 hours. The swath was turned over once during that period. The raw material was harvested with a SIPMA roll baler. Only up to 1.5 ha of grassland was mown at a time, to closely monitor the wilting process. In order to protect them from adverse weather conditions, round bales were tightly wrapped using McHale self-loading round bale wrapper. The time between the formation of respective bales and the wrapping of respective bales did not exceed 20 minutes. The bales were wrapped with four layers of white stretch film, 30 micrometers in thickness. Bale density (kg SM/m^3) was determined based on average bale weight, the average dry matter content of silage and bale volume. Average bale weight was estimated based on the values recorded during the feeding trial. Bale volume (1.35648 m^3) was calculated assuming a cylinder model 1.20 m in height and 1.2 m in diameter. Corn silage was made from medium-early cv. Gazelle (FAO 220), in a clamp silo. Raw material for ensiling was harvested at the dough stage (5 October), with a self-propelled forage harvester equipped with a forage crusher (theoretical straw length - 9 mm).

The study involved a total of 130 Holstein-Friesian cows kept in free stall barns, divided into two feeding groups based on lactation stage and productivity. Group 1 (65 cows) received silage made from green fodder wilted for 6 h, and group 2 (65 cows) received silage made from green fodder wilted for 24 h. Experimental silage was offered *ad libitum* during 60-day proper periods preceded by 15-day adaptation periods. Both groups were also given a constant amount of corn silage (15 kg/head/day) and the same type of pelleted concentrated feed. Corn silage was administered in the morning, together with experimental silage. In the afternoon cows received experimental silage only. Roughage was supplied from a feed cart with a horizontal working unit. The amount of experimental silage fed to cows was recorded daily, with the use of automatic balances on feed carts. Concentrated feed was dosed individually from automatic feed stations, using the animal identification system. Cows whose milk yield exceeded 16 kg received concentrate in the amount of 0.5 kg/kg milk. Starting from day 100 of lactation, the daily concentrate ration determined at the beginning of the feeding trial remained unchanged. In earlier phases of lactation the quantity of concentrated feed varied depending on milk yield.

Feed intake was estimated as a sum of the average daily intake of experimental silage and corn silage, and individual consumption of concentrate (Andersen et al. 2003). The results regarding experimental silage are presented as average MD intake and ECM yield. The proximate chemical composition of grass-alfalfa silage, corn silage and concentrated feed was determined by standard methods (AOAC 1990). The dry matter content of silage was corrected relative to volatile substances, according to the Haigh equation (1995) for baled silage:

corrected DM (g/kg) = 17.9 + 0.99 oven-dried DM (g/kg) (R^2=0.99) Water-soluble carbohydrates (WSC) were determined by the DREYWOOD method (Rutkowska et al. 1981), and NDF, ADF and ADL were determined as described by GOERING and VAN SOEST (1970), with the use of ANKOM 220 (silage) or Foss Tecator Fibertec 2010 (concentrated feed). The pH of silage was measured with a HI 8314 pH-meter. The concentrations of acetic acid, butyric acid and propionic acid were determined by gas chromatography with flame-ionization detection (type 6890). Lactic acid content was determined by HPLC. The content of protein nitrogen and ammonium nitrogen was estimated by the Bernstein method and the Conway method respectively (Skulmowski 1974). Ethyl alcohol content was measured as described by Weissbach–Laube (1964). The nutritive value of feed was determined according to INRA (2001), based on chemical composition, using WINWAR software. The milk yield of cows was monitored twice daily in milking parlors, and converted to kg of standardized milk relative to the energy value of ECM (Huhtanen et al. 2002):

ECM (kg) = milk (kg) [38.3 fat (g/kg) + 24.2 protein (g/kg) + 783.2]/3140

The content of fat, protein and urea, and somatic cell count (SCC) were determined in milk samples collected during trial milking. Average SCC in milk is presented as a natural algorithm (ln). Feed utilization was estimated based on the quantity of ECM produced per kg DM of the ration, concentrate intake, UFL and PDI per kg ECM, and milk protein synthesis efficiency described as a ratio of average daily protein yield to average PDI intake.

The results of tests on animals were verified by a one-factor analysis of variance, to determine the effect of preservation method on ECM yield. Statistical calculations were performed using STATISTICA7 software.

Results. Bale silage made from grass and alfalfa wilted for 24 h was characterized by higher density than bale silage made from grass and alfalfa wilted for 6 h (Table 1). Prolonged wilting caused a significant ($P \leq 0.01$) increase in the concentrations of dry matter and water-soluble carbohydrates in silage and a decrease ($P \leq 0.01$) in total protein content. No significant differences were found in the pH values of silage, although the levels of lactic acid ($p<0.05$) and volatile fatty acids ($p<0.01$) were higher in silage with a higher moisture content.

Table 1. **Chemical composition and nutritive value of grass and alfalfa, maize silage and concentrate**

Item	Wilted: grass, alfalfa, silage			Maize silage	Concentrate
	6h	24h	SE		
Bale density kgDM/m^3	128,5	148,8			
Dry matter g/kg	249,9A	374,9B	5,54	330,0	889,1
pH	4,62	4,79	0,21	3,90	
In g/kg DM:					
-organic mater	899,6	904,8	4,06	956,7	915,0
-crude protein	191,5A	178,9B	2,11	77,2	233,3
-water soluble carbohydrates	30,3A	82,7B	1,12	12,5	
-NDF	480,2	501,2	4,22	453,5	157,9
-ADF	356,2	367,5	3,84	267,6	76,8
-ADL	58,1	43,9	1,52	29,4	
Products of fermentation:					
-lactic acid	125,5a	98,7b	0,85	95,32	
-acetic acid	37,3A	11,2B	0,19	23,96	
- propionic acid	0,18	0,03	0,05	0,21	
- butyric acid	0,36	0,08	0,04		
- total acid	162,8A	110,7B	1,08	119,49	
- lactic acid/ total acids%	77,8	89,9	0,99	79,7	
- ethanol	12,46	12,56	0,47	23,89	
-N-protein	13,5	12,6	0,62		
-N-NH_3	1,65	1,01	0,06	0,91	
-N-protein/ N-total g/kgN	441,0a	493,4b	2,28		
-N-NH_3/ N-total g/kgN	53,9	35,5	1,15	73,0	
Nutritive value:					
UFL	0,89	0,87	0,02	0,89	1,18
PDIN	111,47	104,24	1,42	61,2	133,0
PDIE	65,40	68,65	2,51	68,5	148,5
FUC	1,29	0,96	0,02	1,03	

A,B $P \leq 0,01$ a,b $P \leq 0,05$

Ammonium nitrogen content and the ammonium nitrogen to total nitrogen ratio were higher in silage with a higher moisture content, but these differences were statistically non-significant. The degree of green forage wilting had a significant effect ($P \leq 0.05$) on protein degradation in the ensiling process. The rate of protein degradation was faster in silage made from raw material wilted for 6 h, compared to silage made from raw material wilted for 24 h. Silage produced from green forage wilted for 6 h was marked by higher concentrations of net energy and PDIN, and by a lower PDIE content and feed value (non-significant differences). Average dry matter intake of experimental silage and total feed intake were similar in both groups (Table 2). The intake of net energy and PDI was also comparable, but PDIN level was slightly higher than PDIE level in both groups.

Grass-alfalfa silage with a different degree of wilting had no effect on average milk yield, ECM yield, the protein content of milk, or the average daily yield of milk protein and milk fat per cow (Table 2). Only the fat content of milk was higher ($p<0.05$) in the group of cows fed silage with a lower degree of wilting. Milk from cows given silage with a higher moisture content had a higher concentration of urea ($p<0.01$). There were no differences between the two feeding groups with respect to the utilization of dry matter, energy and protein. An analysis of the milk performance of cows at particular stages of lactation (Table 3) revealed that starting from day 200 of lactation, milk production was higher ($p<0.05$) in cows fed silage with a higher degree of wilting. However, due to a lower fat content of milk ($p<0.05$) these differences were found to be statistically non-significant when converted to ECM.

Table 2. **Mean treatment effects on intake, milk production and nutrient utilization**

Item	Group		
	1	2	SE
Intake/day			
Dry matter kg			
Grass and alfalfa silage	8,62	8,35	0,36
Forage	13,57	13,30	0,49
Total	20,71	20,68	0,71
UFL	20,51	20,38	0,55
PDIN g	2206,1	2147,5	36,4
PDIE g	1963,1	2008,2	41,7
Yield kg/day			
Milk	31,82	32,57	1,06
ECM	31,65	31,71	1,05
Fat	1,27	1,27	0,03
Protein	1,02	1,05	0,03
Milk composition			
Fat g/kg	39,91[a]	38,20[b]	0,43
Protein g/kg	32,93	32,45	0,35
Urea mg/l	243,2[A]	207,24[B]	5,37
SCC LN	11,93	11,84	0,12
Nutrient utilization			
ECM/DM kg/kg	1,52	1,53	0,01
Concentrate 1/kg ECM	0,27	0,26	0,01
UFL/1kg ECM	0,65	0,63	0,01
PDI/ECM g/kg	58,17	58,07	0,45
Milk protein/PDI intake g/g	0,57	0,57	0,01

A,B P≤0,01 a,b P≤0,05

Table 3. **Yield and milk composition at particular stages of lactation**

Item	Days of lactation								
	<100			101-200			>200		
	Group								
	1	2	SE	1	2	SE	1	2	SE
n	12	12		34	34		19	19	
Milk kg/d	40.93	41.94	2.00	32.20	32.93	1.02	23.31[a]	25.95[b]	1.01
ECM kg/d	37.34	36.98	2.41	32.62	33.10	1.12	25.42	26.91	1.11
Fat g/kg	35.46	32.52	0.93	41.25	41.56	0.69	46.57[a]	42,76[b]	0.94
kg/d	1.45	1.36	0.13	1.32	1.37	0.06	1.07	1.10	0.04
Protein g/kg	30.02	30.58	0.53	32.73	32.20	0.44	35.60	34.27	0.79
kg/d	1.23	1.28	0.07	1.05	1.06	0.03	0.82	0.88	0.04
SCC LN	11.31	11.39	0.37	11.84	11.88	0.17	12.44	12.06	0.21
Urea mg/l	201.42	202.17	12.03	263.38[A]	204.53[B]	9.09	233.95[a]	214.9[b]	9.87
Days of lactation	55.0	56.33	8.35	149.5	155.0	4.43	291.1	290.8	11.67

A,B P≤0,01 a,b P≤0,05

Discussion. The chemical composition of experimental silage indicated the normal course of the ensiling process of grass and alfalfa in round bales. A lower lactic acid concentration and a higher WSC content confirmed the inhibitory effect of wilting on the activity of carbohydrate fermenting microflora (Yan et al. 1998, Brzóska et al. 1999, Wright et al. 2000). Prolonged wilting limited also the activity of *Clostridium sp.* and *Enterobakteriacea,* which was reflected in a lower content of volatile fatty acids in silage (McDonald et al. 1991). A higher degree of wilting was accompanied by reduced deamination activity of *Clostridium sp*., which is consistent with the results obtained by other authors (Driehuis, Van Wikselaar 2001, Slottner and Bertilsson 2006). The protein nitrogen to total nitrogen ratio was indicative of a low degree of proteolysis. This corresponds to the findings of Slottner and Bertilsson (2006), who reported that the ensiling of green fodder in round bales, in comparison with the ensiling of chopped crop in silos, reduces the extent of proteolysis. The inhibitory effect of pre-wilting on protein hydrolysis during ensiling has been also confirmed (McDonald et al. 1991, Wright et al. 2000).

The feeding trials performed on dairy cows showed that the degree of high-protein crop wilting prior to ensiling in round bales had no influence on average productivity (kg ECM). The average yield of milk and ECM was high and comparable to that attained in HF cows fed diets supplemented with grass, legume and corn silage (Friggens et al. 1998, Broderrick et al. 2000, Keady et al. 2002, Onetti et al. 2004, Groff and Wu 2005). The differences in milk performance observed between group 1 and group 2 cows starting from day 200 of lactation resulted most probably from a lower concentrate content of the ration. Production results could be related to differences in the supply of nutrients absorbed from experimental silage (Steen et al. 1998, Dawson et al. 1999, Broderrick et al. 2001), caused by certain changes in both silage composition and fermentation profile (Huhtanen 2003, Givens, Rulquin 2004). In the present study, silage with a higher dry matter content had higher concentrations of protein nitrogen and water-soluble carbohydrates. According to other authors (Jones 2000, Winters et al. 2001), this affects microbial protein synthesis and the content of protein that is not degraded in the rumen. Ferris et al. (2001) demonstrated that silage quality considerably influenced milk yield in high-producing cows only when the concentrate content of the diet was low. The effect of silage quality decreased along with an increase in the proportion of concentrated feed in the ration.

The present results seem to confirm the hypothesis that silage intake by cows is dependent not only on preservation method, but also on the concentrate content of the diet and on the average daily consumption of concentrated feed (Huhtanen et al. 2002, Keady et al. 2004, McNamee et al. 2005). An increase in the level of concentrate supplementation is accompanied by lower roughage intake and higher productivity (Kuoppola et al. 2004), while a decrease in concentrate supply is not always followed by lower milk production, particularly in medium-producing cows (Dillon et al. 2002). Brzóska et al. (1995) reported that roughage quality had no effect on the composition and physicochemical properties of milk, despite increased silage intake by cows. According to the authors, this resulted from the fact that the nutritional needs of cows had been met regardless of the type of silage offered. Studies on the species composition of high-protein silage (Cherney et al. 2004), as well as on the pre-wilting of green forage and the use of ensiling agents (Gąsior, Brzóska 2000), revealed that the above factors had no significant effect on milk production in cows fed high-concentrate diets. Cow performance was not affected by varying proportions of alfalfa and corn silage (Groff, Wu 2005) or hay and silage in corn silage-based diets (Onetti et al. 2004), either.

Conclusions. The results of a study on grass-alfalfa silage fed to dairy cows together with corn silage and concentrated feed indicate that the different degree of green forage wilting prior to ensilage has no effect on average milk yield, milk composition and feed utilization.

Cow productivity may not constitute the only criterion for a biological evaluation of roughage preservation methods, particularly with regard to high-concentrate diets.

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