THE SILAGE COMPOSITION AND ITS INFLUENCE ON DAIRY COWS MILK YIELD

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Abstract. *The purpose of the research was to analyze the composition of maize and grass silages and estimate influence of forage: concentrate ratio on milk yield in dairy cows. Data were collected in 2013 and 2014 and consist of 11 samples of maize silage and 15 samples of grass silage. Dry matter (DM) content was not significantly different between years within silage group. Dry matter content of maize silage was 317.2 ± 15.14 g kg^{-1} in 2013 and 361.5 ± 20.61 g kg^{-1} in 2014, whereas corresponding DM in grass silage was 303.8 ± 17.58 g kg^{-1} and 361.5 ± 20.61 g kg^{-1}. Crude protein content of DM was significantly higher in grass silage than in maize silage and ranged from 123.9 ± 8.07 g kg^{-1} to 137.5 ± 7.12 g kg^{-1}. Net energy for lactation (NEL) was significantly higher in maize silage than in grass silage and ranged from 6.5± 0.09 MJ kg^{-1} to 6.6 ± 0.06 MJ kg^{-1} of DM (P<0.05). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) content of DM was lower in maize silage than in grass silage. The range in NDF was from 444.1 ± 12.40 g kg^{-1} to 487.1± 17.79 g kg^{-1}, whereas corresponding ADF ranged from 252.9 ± 7.76 g kg^{-1} to 254.4 ± 7.76 g kg^{-1}. The relationship between NEL and DM content was: NEL=0.0007×DM + 6.3317. Highest forage: concentrate dry matter ratio was 1.24 in May, 2013, whereas highest milk yield was observed in May, 2014.*

Key words: *maize silage, grass silage, forage: concentrate ratio.*

INTRODUCTION

Quality of forage is one of important factors affecting milk quality and quantity in the dairy sector. The production of high quality raw milk is necessary for further processing of raw milk for a high quality food production. A balanced diet for dairy cows provides the nutritional requirements for getting this high quality milk. In many countries, silage constitutes 50 to 70% of dairy cow diets and contribute to a high milk yield [9]. To do that, the diet must contain enough energy and essential nutrients. In that respect, dry matter and composition of dry matter is important. The important nutrients are crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), starch, crude fat and sugars. Concentration, digestibility and utilization of them determine net energy for lactation (NEL). Quality of forage is affected by factors like botanical composition, climatic conditions, harvesting technology and others [1]. Maize silage is used for elevation of energy of the ration, but nutritional value of this silage is affected by agro-climatic conditions and sowing time [10]. Protein is one important component in high-yielding dairy cows feed rations. In addition to milk yield and quality, the balance between protein and energy affect reproduction traits also [4]. Grass silage is one of important feedstuff that provides protein to for dairy cow feed rations. The process of ensilaging is very important to preserving the protein quality in silage [5]. Legumes like alfalfa provides high content of protein in silage [3]. Fermentation and digestibility in cattle rumen differ between silage types like maize silage, crop silage, grass silage and alfalfa silage. For example, NDF digestibility was higher for grass silage compared with wheat silages [23]. For both silages, adding concentrates to total mixed ration (TMR) is the best solution for balancing energy and protein requirements. However, the quality of silages affected the proportion of concentrates in TMR. Increasing concentrates in TMR increase not only milk yield, but change milk composition also [26]. Moreover, high producing dairy herds attempting to maximize energy intake are continually confronted with subclinical acidosis and laminitis. These diseases are results of unbalanced dairy cows feeding [21].
The purpose of research was to analyze the composition of maize and grass silages and estimate influence of forage: concentration ratio on dairy cows milk yield.

MATERIALS AND METHODS

The location of research was Latvia University of Agriculture Training and Research farm. Data were collected from 2013 and 2014 and consists of 11 samples of maize silage and 15 samples of grass silages. Samples of

silage were collected by using silage probe in the full depth of the pit along two intersecting diagonals. The samples of silage were inserted in polyethylene bags, which protected them from environment impact. Average weight of the silage samples were 0.5 to 1.0 kg. The samples were analyzed in LUA Scientific Laboratory of Agronomic analyses according to international methodology (Table 1).

Table 1

Analyzing sample count and methods

Traits	Sample count (n)	Method
Dry matter	26	Forage analyses, USA, met. 2.2.1.1:1993, *met. 2.2.3.:1993
Crude protein	26	LVS EN ISO 5983-2:2009
NDF	26	LVS EN ISO 16472:2006
ADF	26	LVS EN ISO13906:2008
Ash	15	ISO 5984:2002/Cor 1:2005
Ca	16	LVS EN ISO 6869:2002
P	16	ISO 6491:1998
pH	15	ГОСТ 26180-84, met.3
Starch	11	LVS EN ISO 10520:2001
NEL	26	Calculated by formula: (0.00245×digistibility of DM-0.12)×4.184

Data of dairy cows feed ration and milk productivity were collected from monthly milk recording results until 110th lactation day (high-yielding group). The cows were kept in a loose housing system and fed with TMR. The TMR contained 34-50 kg forage (respectively 60% grass silage, 40% maize silage, 1.0 kg hay). The remaining part was concentrates (6.8- 7.0 kg barley flour, 2.5-2.8 kg rapeseed cake, 2.0-2.5 kg soybean cake, 0.3-0.4 propylene glycol, 1.0 kg molasses, 0.5 kg energy feed, 0.2 kg mineral (SelenPlex, Biotin Plus et al.), 0.15 kg chalk, 0.25 kg banking soda, 0.04-0.06 kg salt). Digestibility of dry matter in maize silage was 68% in 2013 and 69% in 2014. Corresponding digestibility of grass silage was 60% in 2013 and 59% in 2014. The cows were fed 2 times per day and milked 3 times per day in parallel milking parlour. The cows were from different breeds (Holstein Black and White, Holstein Red and White, Danish red, Latvian brown with different blood) and lactations and averaged 2.5 lactations in 2013 and 2.1 lactation in 2014.
Forage: concentrate ratio was (F:C ratio) was calculated according to formula:

$$F:C \quad ratio = \frac{F}{C}\ , \tag{1}$$

where: F – forage dry matter weight, kg
C – concentrate dry matter weight, kg.

The data processing was carried out with SPSS and MS Excel programs. T tests for independent samples was used for determination of significant differences between treatments ($P<0.05$).

RESULTS AND DISCUSSION

The composition of grass and maize silage is presented in the table 2. Dry matter of maize silage was 317.2 ± 15.14 g kg^{-1} and 361.5 ± 20.61 g kg^{-1} in 2013 and 2014, respectively, but not significantly different between years. According to other studies, DM of maize silage can range between 230 to 380 g kg^{-1} dependent on harvesting time and other factors [24], [6]. Dry matter of grass silage was 303.8 ± 17.58 g kg^{-1} the first year, and increased to 321.00 ± 21.58 g $kg^{-1}$the second year Similar to maize silage, DM was not significantly different between years. Dry matter content in silage affect DM intake. For example, if DM is lower than 250.0 g kg^{-1}, dairy cows eat enough silage and concentrate content in TMR must be increased [11]. Crude protein of DM was higher in grass silage than in maize silage. Highest crude protein content was 137.5 ± 7.12 g kg^{-1} DM in 2013. According to other studies, average crude protein content of DM was

124 g kg^{-1} in grass silage, compared to 144 g kg^{-1} in grass and red clover mixture silage [14]. Crude protein of DM ranged of 77.4 ± 4.49 g kg^{-1} to 80.5 ± 1.60 g kg^{-1} in maize silage, which is lower than 85.0 g kg^{-1} reported by USA scientists' [7].

NDF content of DM was higher in grass silage than in maize silage both years. Highest NDF content of DM was 566.3 ± 23.10 g kg^{-1} in grass silage in 2014, whereas highest NDF of maize silage DM was in 487.1 ± 17.79 g kg^{-1} in 2013. NDF content of maize silage DM was similar to other research results [27]. However, NDF values of our study were high compared with Dutch studies. The additives and harvesting time affected ensiling process of silage [8].

ADF content of DM was higher in grass silage than in maize silage. Highest ADF content of maize silage was found in 2014 and was 254.4 ± 7.76 g kg^{-1}. ADF of grass silage DM was also highest in 2014.

NEL of maize silage DM was higher than in grass silage DM both years, with highest values found in 2014. Energy value of maize silage DM is depends on the cultivar and the harvesting time [12]. Evaluating the traits mentioned above, we concluded that the quality of both silages is good for dairy cows diets.

Table 2

Silage composition

Component	Grass silage		Maize silage	
	2013	2014	2013	2014
Dry matter, g kg^{-1}	303.8 ± 17.58	321.0 ± 21.58	317.2 ± 15.14	361.5 ± 20.61
Crude protein, g kg^{-1} DM	137.5 ± 7.12	123.9 ± 8.07	77.4 ± 4.49	80.5 ± 1.60
NDF, g kg^{-1} DM	535.3 ± 15.93	566.3 ± 23.10	487.1 ± 17.79	444.1 ± 12.40
ADF, g kg^{-1} DM	373.8 ± 13.08	387.7 ± 16.25	252.9 ± 7.76	254.4 ± 7.76
NEL, MJ kg^{-1} DM	5.7 ± 0.13	5.5 ± 0.13	6.5 ± 0.05	6.6 ± 0.06
Ca, g kg^{-1} DM	11.9 ± 2.0	8.8 ± 1.30	-	1.52 ± 0.50
P, g kg^{-1} DM	2.9 ± 0.10	2.4 ± 0.2	-	1.83 ± 0.6
Starch, g kg^{-1} DM	-	-	271.8 ± 15.3	308.9 ± 15.7
Ash, g kg^{-1} DM	86.5 ± 7.20	-	40.1 ± 3.45	85.7 ± 6.59
pH	4.49 ± 0.22	-	3.88 ± 0.70	-

A balance between NDF, ADF and NEL in TMR are important for high milk yield and health of dairy cows. NDF content of TMR should not be lower than 280.0 g kg^{-1}, of which 75% must be provided from forage. However, it is important to take into account that NDF affect DM intake. Therefore the content of NDF cannot be too high. Starch content is an important component in maize silage and needs to be assess in TMR, especially in early stage of lactation when the papillae is not adapted for intensive fermentation [29]. ADF is an important factor for feed digestibility [12].

Calcium content of DM was highest in grass silage in 2013 and reached 11.9 ± 2.00 g kg^{-1}. Ash, starch and pH were analyzed for the half of the total samples. Ash content of DM significantly differed between maize and grass silages ($p<0.05$). Highest ash content was found in grass silage in 2013 and averaged 86.5 ± 7.20 g kg^{-1}. Increased ash content can be connected with silage harvesting process and soil part pick up from field [15]. Other scientists have found similar results of ash content in grass and maize silage. According to them, ash content of DM should not be higher than 100 g kg^{-1} [19],[16].

In the analyzed period, pH value of the grass silage was 4.49 ± 0.22, whereas pH value of the maize silage was 3.88 ± 0.70.

The relationships between NEL and DM in silages are illustrated in Figure 1. Analyzing the relationship between DM and NEL, we found that increased DM of maize silage by 1 g increased NEL by 0.0007 MJ kg^{-1} of DM, whereas in grass silage the increase in NEL was 0.0032 MJ kg^{-1} of DM. This effect can be explained by fact that starch accumulate as plants are aging. According to investigation carried out in Lithuania, NEL value increased by 0.043 MJ kg^{-1} of DM if DM increased by 10 g kg^{-1} [25].

There was a weak positive correlation between DM content and NEL in maize silage (r_p = 0.23). In grass silage the correlation was r_p = 0.46. The best influence on rumen environment and silage digestibility have been reported to be when DM content of silage was 300-400 g kg^{-1} at harvesting time [2].

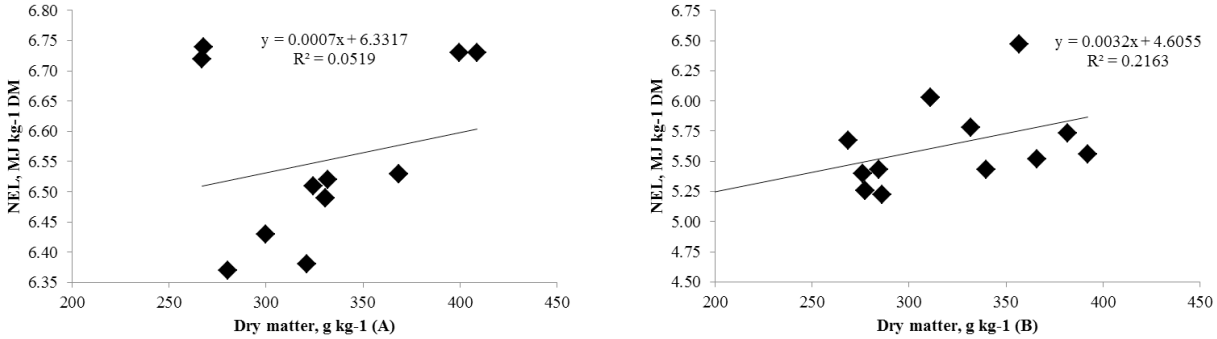

Figure 1. **Relationship between NEL and DM (A – maize silage, B – grass silage)**

Forage: concentrate ratio characterize the dry matter of forage and concentrate relationship in TMR. Our research results of F:C ratio and milk yield are illustrated in Figure 2. If F:C ratio value is higher, it means that forage content increased in TMR. Lowest F:C ratio was found in November 2014 when it decreased to 0.78.

Highest daily milk yield was found in May 2014 when it averaged 42.3 kg. At the same time, F:C ratio was 0.89. We found that the trend was that milk yield increased when forage content decreased and concentrate content increased in TMR. In early lactation stage, the intake of more concentrates is important to avoid negative energy balance [13]. Dutch scientists that, analyzed influence of TMR on dairy cows milk productivity with F:C dry matter ratio of 0.45, or only 35% forage dry matter in TMR, found a milk yield that increased to 48.0 kg [28].

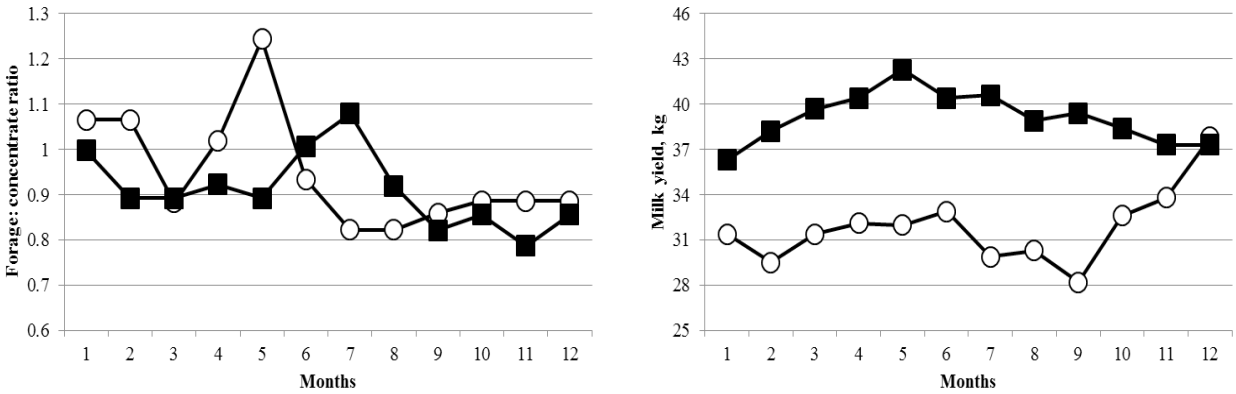

Figure 2. **Forage: concentrate dry matter ratio and milk yield: ○ 2013; ■ 2014 year**

Milk yield can be affected by different factors, for example, grass and maize silage ratio and ingredients of concentrate. Merten recommends that optimal value of F:C dry matter ratio should be between 0.7 and 1.5. The risk of developing different diseases, for example, acidosis, lameness increase when F:C ratio is lower and it can end with culling of dairy cows [17],[18]. Our results are in line with Merten's recommendations. It is important not only to get a high milk yield, but also to produce it profitable. Controlling forage harvesting and dairy cows feeding process is important for dairy cows longevity and environment protection. This and the health of dairy cows can be achieved by use of balanced diets [20].

CONCLUSIONS

Dry matter content was not significantly different between years in each silage group. Highest DM content was in maize silage in 2014 and averaged 361.5 ± 20.61 g kg^{-1}.

Chemical composition was not significantly different between years in each silage group. Crude protein of grass silage DM was highest in 2013 (137.5 ± 7.12 g kg^{-1}), whereas highest NEL of maize silage was found in 2014 (6.58 ± 0.06 MJ NEL kg^{-1}). There was a positive correlation between DM and NEL of r_p = 0.23 in

maize silage and r_p= 0.46 in grass silage. Highest milk yield was observed in 2014, when forage to concentrate dry matter ratio was lower.

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