Effect of replacing grass hay with maize silage as a basal diet on milk yield and composition of dairy cows

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ABSTRACT

The objective of this study was to determine effect of replacing grass hay with maize silage on milk production and composition. The study was conducted at Haramaya University dairy research farm -using sixteen crossbred dairy cows (Zebu × Holstein-Friesian) which were assigned to two treatment groups. Each treatment group consisted of eight cows and arranged in a completely randomized experimental design. Cows in both treatment groups were provided similar supplemental concentrate ration formulated from various ingredients but fed on different basal diets which were silage and grass hay. The feeding trial was conducted for a total of 90 days. Milk yield of individual cows were recorded every day and analyzed every two weeks for its chemical composition. Data were analyzed by t-Test for means. The group of cows fed on grass hay relatively produced higher milk yield (17.1) than cows fed on silage (16.1 liters per day). The protein, total solid, solid not fat, and milk urea nitrogen composition were found significantly different between a group of cows fed grass hay and silage. Silage-fed cows gave higher percentage of fat and protein content throughout the experimental period. Milk urea-nitrogen concentration was intensive in cows fed on hay and it was higher than the acceptable range (12 to 18 mg/dl) for the two experimental diets. In conclusion, farmers could use both grass hay and maize silage as substitute to each other in dairy cow diets that could ensure higher quantity and quality milk production.

Keywords: Grass hay; Milk composition; Milk yield; Maize silage
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INTRODUCTION

In developed countries, maize silage is the main ingredient of diets fed to lactating cows in the commercial dairy farms (Guggisberg, 2011). Maize has favorable characteristics for silage production because it offers a good yield of dry matter (DM) per hectare and has high nutritional value (Viana *et al*., 2012). However, the technology used in maize silage demands considerable investment,

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i.e., technical and financial resources (Sousa *et al*., 2009). Maize cultivation also suffers from bottlenecks such as recurrent drought, mycotoxin contamination, plant attack by specific parasites and insects. During the last few years, dairy farmers have considered the use of alternative forage sources such as hay (Cattani *et al.,*2017).Hay is defined as air-dried crop to 18-22 percent moisture whereas silage or ensilage has undergone an anaerobic composting where sugars are fermented under acidic conditions (Van Soest, 1994).The definition of hay and silage is particularly reflected in the dry matter content of the preserved crops, whereby DM varies from 79.7% to 92.1% for hay and from 25.6% to 50.2% for silage (McDonald *et al*., 1991). McCormick *et al.* (2011) reported significant difference in nutrient composition of silage compared with hay. There seems to be a tendency of higher crude protein and lower neutral detergent fiber (NDF) content in silages compared to hay.

Conserving forage as silage will most likely cause loss of nutrients through fermentation, oxidation and effluent; whereas, conserving as hay can cause a loss through leaf shattering (Van Soest, 1994). McGechan (1989) reviewed field losses during conservation of grass forage and found that total respiratory loss of dry matter increases over time (during field wilting) and total mechanical loss of dry matter increases with increasing dry matter content. Dry matter loss during storage was reviewed by McGechan (1990) who found a loss of 2 to 5% in hay and as much as 20% in silage. Nelson and Satter (1990) attributed the higher content of NDF in hay (52.3 vs. 51.5% of DM) to a greater loss of leaves.

The sale of dairy products made of milk from hay fed cows instead of silage fed cows has increased substantially over the past few years (Guggisberg, 2011) and this is because products like cheese made from silage-based milk tended to be bitter (Martin *et al.*,2005). One direct comparison of hay and silage on its nutrient content was conducted in 1937 (Olesen *et al*., 1937). However, a number of factors may cause one to query the comparability of these experiments to modern day standards. In a review on cheese sensory characteristics, Martin *et al.* (2005) compared the effect of hay and silage and concluded that cheese made from silage-based milk tended to be bitter and varied more in sensory characteristics within a batch of cheeses. Furthermore, Kalac (2011) concluded in a review that the transfer of some components from silage to milk can be of concern, and mentioned spore-forming bacteria to be a potential problem as they can spoil milk during processing. Verdier-Metz *et al.* (2005) used a taste panel and found that whenever a difference in sensory characteristics was significant, this difference was always to the benefit of the hay-based cheese.

In Ethiopia, hay contributes about seven percent of livestock feed at national level (CSA, 2017). However, silage preparation is not common under most

conditions of Ethiopia because maize is mainly used as human food instead of silage. Moreover, the effect of using silages on animal performance depends on the quality of the silage and the nutrient availability (Mizubuti *et al.,* 2002). According to the literature search, recent comparison of the performance of lactating dairy cows fed either hay or silage-based rations is limited. Such a comparison is important in order to improve the decision basis for dairy farmers who are considering switching from silage to hay or vice versa. Therefore, the objective of this study was to determine the comparative effects of silage and hay feed on milk yield and composition of Holstein Friesian crossbred dairy cows during the early lactation stage.

MATERIAL AND METHODS

Study Area

The study was conducted at Haramaya University dairy farm, located at 527km east of Addis Ababa, 17 km from the city of Harar and 40 km from Dire Dawa. The elevation of the area is about 2000m above sea level and geographically it is located at 041°59′58″latitude and 09°24′10″longitude. The area receives an average annual rainfall of 900mm. Agro-ecologically, 66.5% of the area is midland and 33.5% of it is lowland. The mean maximum temperature of study area is 24.18 °C and the minimum is 9.9 °C. About 63,723 cattle, 13,612 sheep, 20,350 goats, 15,975 donkeys, 530 camels and 42,035 chickens are found in the study area (Unpublished data from District Agricultural office, 2017/2018).

Animal Selection and Management

Among synchronized heifers, sixteen crosses of Holstein-Friesian (HF) dairy cows (> 80% blood level HF cross) in the early lactation stage and first parity were randomly taken from Haramaya University's dairy research farm and assigned to two treatment groups in a completely randomized experimental design.

Experimental animals were allowed seven days of acclimatization to treatment and experimental procedures. Following the acclimatization period, the actual feeding trial was conducted for a total of 90 days. Experimental animals in each treatment group provided individually similar supplemental ration (at a rate of 0.5 kg per 1 kg of milk) formulated from various ingredients on the farm (Table 1) and fed three times a day (at eight-hour intervals). Following concentrate feeding, the first and the second experimental groups of cows were fed on silage and hay in group as *ad-libitum*, respectively.

Maize silage was prepared on farm following the standard procedure but baled hay was purchased from Sululta just nearby Addis Ababa. The cows had free access to water every day. Cows were milked twice a day at equal milking interval (12 hrs). Milking was conducted in a milking parlor using a milking machine following the standard milking procedure.

Data Collection

Representative fresh samples of silage and dry samples of hay were collected for chemical composition analysis before the start of the experiment (Table 1). Samples of silage and hay were analyzed in duplicate for DM, N, EE, NDF, ADF, ADL and ash according to AOAC (2012). Milk yield was recorded every day and 100 ml milk samples from the morning and afternoon/evening milking were separately collected from each cow after thorough mix and pooled for each experimental group. Average of milk samples collected at the beginning of the experiment and every two weeks after the commencement of the experiment was taken and the composite samples were analyzed for fat, protein, casein, lactose, FFA, Density, milk urea nitrogen (MUN) contents of the milk by MilkoScan™ FT1 apparatus (Foss Electric, DK-3400, Hillerød, Denmark).

Table 1. Chemical composition of the experimental ration and proportion of ingredients (%) in the concentrate feed.

Ingredients	%	Kg/ton	Average Nutritional Value (%)						
			DM	CP	NDF	ADF	ADL	EE	Ash
Ground corn	56.1	561	89.0	7.1	27.9	3.9	0.6	5.3	2.3
Wheat bran	20.6	206	93.1	15.3	43.1	9.5	4.2	4.8	3.9
Soybean meal	5.2	52	93.2	38.5	-	-	-	8.9	8.0
Peanut meal	14.9	149	94.7	37.3	34.7	13.8	6.3	9.6	6.2
Salt	0.7	7	-	-	-	-	-	-	-
Ruminant premix	2.5	25	-	-	-	-	-	-	-
Hay	-	-	95.0	6.7	79.0	43.0	-	1.3	8.9
Maize silage	-	-	94.9	7.7	75.0	41.0	-	2.3	7.6

DM = Dry Matter; CP = Crude Protein; EE = Ether Extract; NDF = Neutral Detergent Fiber; ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin,- Not evaluated/quantified

Statistical analysis

Data entry and management was made using Microsoft Excel sheets and analyzed using the t-test for two samples to ascertain if the null hypothesis can be accepted or rejected at $\alpha<0.05$.The model used to analyze the quantitative

data was: $Yij = \mu + Fi + Eij$, Where: Yij is the J^{th} observation of the i^{th}feed; μ is the population mean; Fj is the feed effect (silage and hay); and Eij is the experimental error.

RESULTS AND DISCUSSION

The result of the study indicated that protein, TS, SNF, and MUN composition of milk was found significantly different between the groups of cows fed grass hay and maize silage (Table 2). Milk yield did not vary between the groups. Similar milk yield and composition was reported before (Beauchemin *et al.*, 1997). In contrast, Kolver *et al*., (2001) reported lower milk production at early lactation stage when cows were fed hay compared to silage.

Though not significant, slightly more milk yield with increasing trend over the experimental period was observed in cows fed hay (Figure 1). Coulon *et al.* (1997) reported a slightly higher milk yield for cows fed on silage (20.2 kg/day) than those fed on hay (19.5 kg/day). This shows that grass hay could be a potential as substitute for maize silage in dairy cow diets for milk production and vice-versa. Maize silage fed cows relatively produced milk with higher components than cows fed hay as basal diet (Table 2). This partially agrees to Beauchemin *et al.* (1997) who reported lower fat and higher protein concentration when cows fed hay instead of silage. Nearly similar to the present finding, for cows fed on maize silage, Cattani *et al.* (2017) reported fat content of 4%, protein of 3.6%, and lactose of 4.9%. High percentage of fat and protein content was observed throughout the study period (Figure 2) in a group of cows fed on silage could be related to high starch and might also be attributed to the high efficiency of microbial protein synthesis on maize silage as compared to hay-based diets which corroborates reported by Fitzgerald and Murphy (1999). In addition, the higher crude protein content of maize silage might favor a group of cows fed on maize silage to produce milk with higher protein. Though not significant, milk components were slightly higher for the diets containing maize silage than the diet with grass hay, except protein, solid not fat, total solids and milk urea nitrogen (Table 2).Milk fat composition showed increasing trend during the first two months for the two experimental diets though it was slightly higher for the group of cows fed on maize silage than grass hay (Figure 2). The lower protein and fat concentration for the group of cows fed on the diet containing hay might be due to their relatively higher milk yield (Figure 1). The concentration of milk protein content revealed an increasing trend throughout the study period for a group of cows fed on maize silage (Figure 2). This might be due to the efficiency of microbial protein synthesis on silage as compared to grass hay-based diets which corresponded to the study reported by Fitzgerald

and Murphy (1999). It is also related to the higher crude protein content of maize silage than grass hay used in the experiment (Table 1).

Table 2. Effect of basal diet on milk production and composition.

Parameters (mean)	**Hay**	**Silage**	***t*- value**	**P-value**
Milk yield (L)	17.1	16.1	-0.664	0.532
Fat (%)	3.5	3.9	1.378	0.190
Protein (%)	3.0[b]	3.3[a]	3.800	0.002
SNF (%)	8.3[b]	8.7[a]	3.906	0.002
TS (%)	12.0[b]	12.6[a]	2.224	0.043
Lactose (%)	4.7	4.7	-0.198	0.850
Casein (%)	2.3	2.4	1.322	0.210
Density	1027.4	1027.9	1.787	0.096
FFA (%)	0.46	0.5	0.233	0.819
MUN (mg/dl)	37.14[a]	33.9[b]	-2.256	0.041

FFA stands for free fatty Acid, SNF for solid not fat, TS for total solid, MUN for milk urea nitrogen; means within the same row with different letters are significantly different at α=0.05.

The higher total solid and solid not fat content of milk from the group of cows fed on silage (Table 2, Figure 2) might be due to the higher protein content of milk from group of cows fed on maize silage. Lactose content was practically constant over the experimental period for cows fed on maize silage; however, it increased and reached peak at day 56 for the group of cows fed on grass hay (Figure 2). In contrast, O'Mara *et al.* (1998) reported increased milk lactose when maize silage included in the dairy diet. Further, Colombini *et al*. (2012) reported no significant change in lactose contents of milk with the replacement of grass-based diet with maize silage. In the present study, lactose content did not vary significantly between cows fed on maize silage and grass hay. Lactose is the main determinant of milk volume (Mech *et al*., 2008). A close relationship between lactose synthesis and the amount of water drawn into milk makes lactose a stable milk component (Pollott, 2004). The increase of milk lactose (Figure 2) for a group of cows fed on hay corroborates reports that claim increased lactose in response to hay feeding (Macleod *et al.*, 1994).

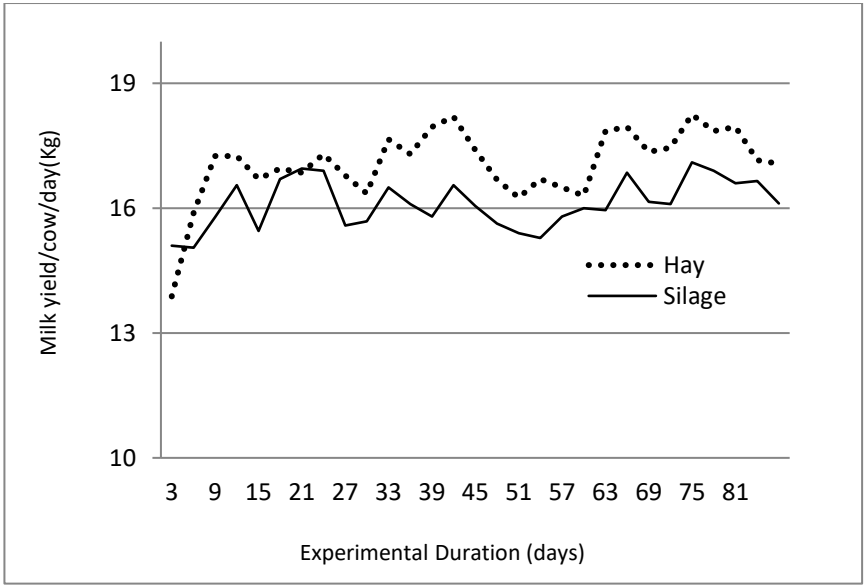
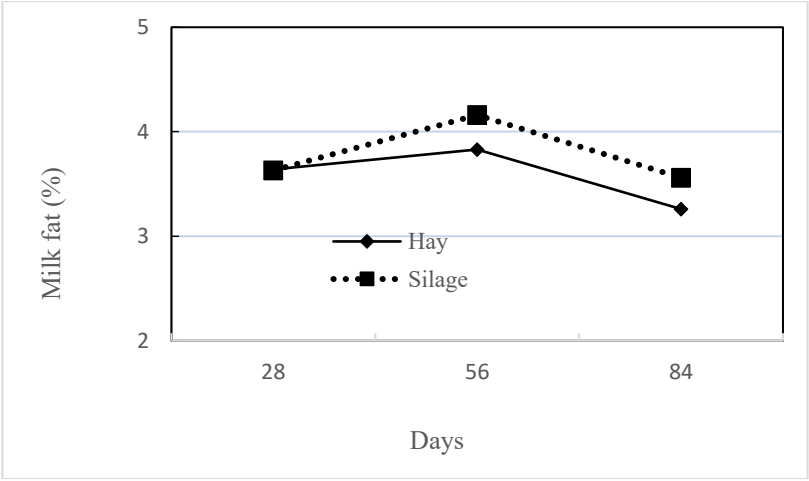
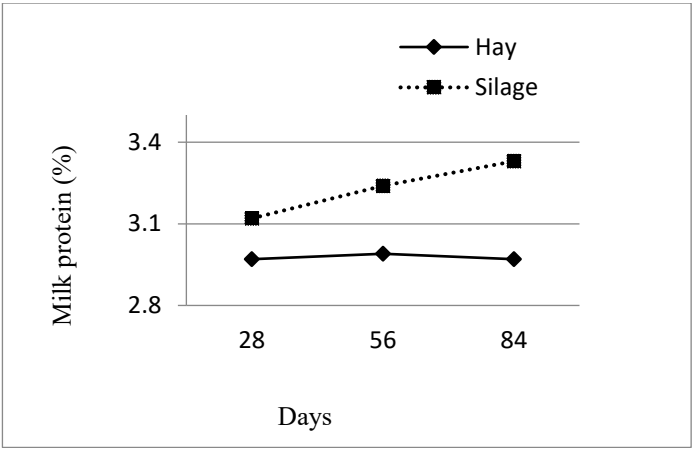
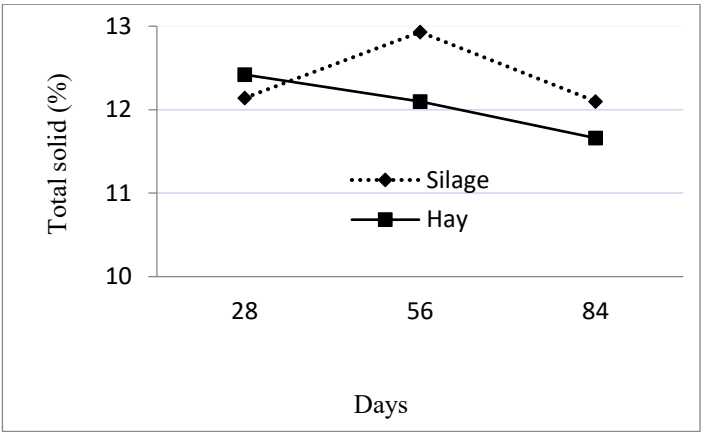


Figure 1. Effect of hay and silage on milk yield of cows




Hay
Silage
Milk protein (%)
3.4
3.1
2.8
28
56
84
Days


Total solid (%)
13
12
11
10
Silage
Hay
28
56
84
Days

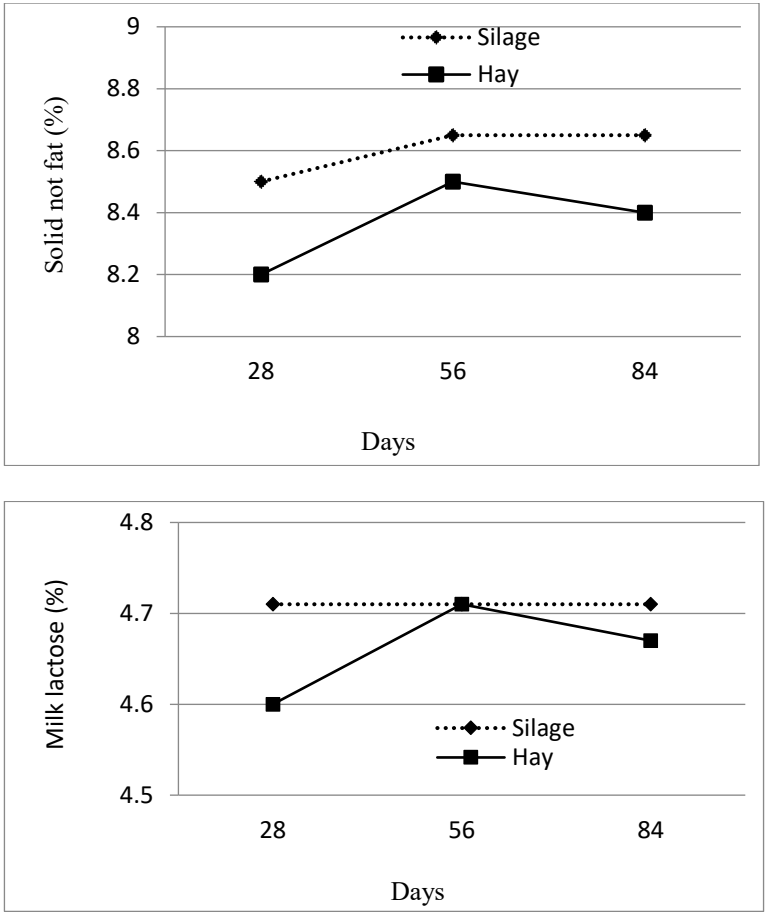


Figure 2. Percentage milk fat, milk protein, total solid, solid not fat and lactose

The MUN concentration significantly varied between cows fed on hay and maize silage (Table 2). The average MUN recorded in this study was higher than the result (22.65+0.7 mg/dl) reported by Ewonetu (2018) for the same breed. The MUN concentrations investigated in this study is very high compared to those data obtained from dairy herds in the USA, which are about 12 to 14 mg/dl (Jonker et al., 2002), in Sweden about 11 to 15 mg/dl (Carlsson and Pehrson, 1994) and in Korean dairy cows 16.68±5.87 mg/dl (Yoon *et al.,*2004). Cattani *et al.* (2017) reported lower milk components of urea (24.01 mg/dl) for cows fed on maize silage. The average MUN concentration observed in the current

experiment was higher than the normal value which is between 10 to 14 mg MUN/dl for a group of cows (herd) and between 8 to 25 mg/dl for individual cows. Although MUN concentration was intensive in a group of cows fed on hay, results for the two experimental diets did not fall within the acceptable range (12 to 18 mg/dl) and this indicates that the experimental diets might be higher in rumen degradable protein, or lower in rumen fermentable non-fiber carbohydrate, or protein and non-fiber carbohydrate. This idea is similar to justification indicated in nutrient requirements of dairy cattle (NRC, 2001).

CONCLUSION

Though not significant, hay fed cows gave more milk yield than cows fed on maize silage. Overall, majority of milk components from cows fed on diet containing silage were slightly higher than cows fed on diet with grass hay. Replacing maize silage with grass hay as a basal diet for dairy cows revealed significant difference (P <0.05) only for protein, solid not fat, total solids and MUN. The MUN concentration in the two treatment groups did not fall within the acceptable range (12 to 18 mg/dl) and this indicated that the experimental ration being used at the farm should be adjusted for crude protein or non-fiber carbohydrate. In conclusion, farmers could use both grass hay and maize silage in substitute to each other in dairy cow diets that could ensure higher quantity and quality milk production.

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