Evaluation of Biological Treatment of Barely Straw on Voluntary Intake and Milk Yield of Crossbred Dairy Cows under Small Scale Farmer's Condition

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Abstract
The study was conducted at on-farm level with crossbred dairy cows at Kofele district, Ethiopia to assess the effect of feeding biologically treated barley straw supplemented with wheat bran on feed intake, milk yield and economic profitability. Twenty six crossbred cows in late lactation stage with an average body weight of 315.8±52.05 kg were randomly assigned into two groups of thirteen cows per group in a Completely Randomized Block Design to conduct the study. Thirteen cows were fed EM treated barley straw in addition to grazing and supplemented with wheat bran at the rate of 1.5 kg/cow/day (T1), and the other 13 cows were maintained as usually practiced by farmers (grazing + 1.5kg wheat bran/cow/day) (T2). Feeding EM treated barley straw supplemented with wheat bran significantly ($P<0.01$) increased feed intake and milk yield of the cows. Due to the improvement in daily milk yield by 2.31 kg (4.98 vs. 2.65 kg), the net return increased from ETB 39.54/cow/day in the control group to ETB 61.90/cow/day in T1 group. This study indicated that the intervention diet increased the net return for farmers to ETB 22.35/cow/day. Feeding EM treated barley straw with wheat bran was found to be an effective approach to maximize the utilization of locally available feed resources for relatively high animal productivity during the dry season for small scale dairy producers in rural areas where there is limited market access for milk.
Keywords: Biological treatment, barley straw, wheat bran, milk yield, profitability

1. Introduction

Crop and livestock production are commonly integrated in the mixed farming system of the mid and high lands of Ethiopia where crop residues particularly cereal straws remain the major feed source for ruminant animals (Solomon, 2004; Zewudie, 2010; Menberu, 2014). Although a huge energy potential is contained in these lignocellulosic crop residues these are not utilized to their full potential for ruminant feeding due to poor digestibility, low nitrogen and mineral contents which reduced them to be classified under non-maintenance type of feeds (Solomon *et al*., 2008; Zewudie, 2010; Girma *et al*. 2014). The nutrient deficiencies affect microbial growth, microbial protein synthesis and overall fermentation in the rumen that further result in low voluntary intake and fiber fermentation and digestibility (Mahesh and Madhu, 2013). The barrier can be removed through biological treatment that increase digestibility by decreasing strength of bonds between lignin and polysaccharides (Van Soest *et al*., 1991; Kilasi, 1998; Russell *et al*., 2011; Peterson, 2014).

Biological treatment of crop residues based on the use of enzyme or microbes have shown to improve palatability and degradability potential and keeping quality of the feed material (Milligan *et al*., 1995). Feeding effective microbes (EM) treated hay supplemented with escape protein resulted in remarkable increase in feed efficiency of stationed lactating dairy cows (Mulugeta, 2015). Biological treatment of maize stover based on the use of enzyme or microbes have shown to improve palatability and degradability potential and keeping quality of the feed material (Milligan *et al*., 1995). Although such information was generated on research station, the efficacy of EM, under farmers condition and treating or ensiling crop residues has not been well evaluated. Therefore, this study was aimed to evaluate the effect of EM-treated barely straw supplemented with bypass protein feed on feed intake and milk yield and economic benefit under on farm condition of small scale crossbreed dairy producers.

2. Materials and Methods

2.1. Description of the study area

The study was carried out at West Arsi zone Kofele district, Wamigne Abosa Kebele which is located 285 km to the South East of Addis Ababa along the main road from Shashamane to Bale Robe at 7^o 7' N latitude and 38^o 30' E longitudes. It has an altitude of 2670 meters above sea level (m.a.s.l). The area is a typical mixed crop livestock production system, where small scale dairying based on crossbred animals are commonly found. Cattle are dominant livestock species in the area while wheat, barley, potato, cabbage and Inset are the major crops produced.

2.2. Experimental animal, design and treatments

The experiment was conducted on late lactating dairy animals of interested sixteen farmers in the study area. Totally twenty six lactating crossbred dairy animals with average body weight of 315.8±52.05 kg and an average milk yield of 2.67±0.41 kg/cow/day were categorized equally into two treatment to participate in the experiment. Cows were weighed before the start of each experiment period and at the end. Experimental cows were hand milked twice a day and milk yield recorded daily. Randomized complete block design (RCBD) was used to conduct the experiment.

The experimental cows were divided into two treatment groups (thirteen cows in each group). Cows of the first group (T1) graze for 8 hours and supplemented with intervention diet (EM2 treated barley straw, wheat bran and salt). Cows in the second group (T2, control) graze for eight hours and allowed to feed untreated barley straw with wheat bran as supplements which is common practices in the study area. During allocation of animals into experimental treatments the level of milk yield and body weight were considered. All the cows were vaccinated against common diseases and drenched with broad-spectrum anti-helminthes (Albendazole 2500mg) prior to the start of the experiment.

2.3. Preparation of experimental feeds

The experimental feeds used in this study were barley straw, wheat bran, effective micro-organism (EM2) and salt. Barley straw was used as basal feed both in treated and untreated forms. The straw was collected manually and stored from farms of each participants. A 20 litter of EM2 solution was prepared by mixing 1 litter EM1 (stock solution) + 1liter molasses + 18 litter water. Then the mixture was stored in a closed plastic container of 25 litter for 20 days to activate the stock solution. After 20 days a litter of activated EM2 solution was extra diluted by 20 litter of water and sprayed thoroughly on 20kg of chopped barley straw on dry matter base on polyethylene sheet of $100m^2$ (10m*10m) and kept in air tighten condition for 10hours for fermentation before fed to animals. Stock EM solution (EM1) to be used for this study was purchased from the recognized distributer (Woljejii PLC, Debrie-Zeit, Ethiopia).

The amount of wheat bran supplemented in this experiment was determined based on the the farmers' practices in the study area. Hence, adjustment of basal feed was made weekly based on the amount of refusal weighed every morning, voluntary intake and milk yield of each cow.

2.4. Data collection and monitoring of experimental animals

Data on body weight change, milk yield and feed intake were recorded over a period of 105 days including an adaptation period of two weeks. Field visits were carried out every two weeks to monitor the body weight change, feed intake and milk yield of the animals. The body weight of cows were measured each fifteen days by using heart girth measurement. All the cows were hand milked twice a day, in the morning and in the evening. Milk yield was measured daily and recorded right at milking. The animals were allowed to drink water two times/day throughout the experimental period. The enumerators recorded daily the intake of roughage and concentrate and milk yield on pre-designed data recording sheet. These sheets were checked at each visit for precision and regularity.

2.5. Financial analysis

A simple partial budget analysis was done based on calculation of the total cost of supplementary feed (concentrate). Milk sales price and labor cost incurred during the entire experimentation process were also considered. The milk price was fixed based on the milk price existing in the study area. The prices of the ingredients used to form concentrate mix were obtained from the current market price during the experimental period. Partial budget analysis was employed to compute total cost of production/cow/day, mean milk yield/cow/day, return/cow/day and net return/cow/day.

2.6. Statistical analysis

Voluntary dry matter intake and milk yield were subjected to General Linear Model (GLM) procedure for RCBD using statistical Analysis System (SAS, 2008). Treatment means were separated using Least Significant Difference (LSD). Differences were considered statistically significant at 5% level of significant. Data generated form monitoring study were analyzed using the following model:

$Yij = \mu + ri + eij$

Yij is the dependent variable (feed intake, milk yield, body weight gain),

μ = overall mean, ri = effect of diet

Xij the record of live weight/milk yield of the jth cow on the ith diet,

eij random variation.

3. Results and discussion

3.1. Chemical composition of experimental feeds

The chemical composition and *in-vitro* organic matter digestibility (IVOMD) of untreated and EM2 treated barley straw in Table 1 shows that EM treatment increased the crude protein content and *in-vitro* digestibility of barley straw by 113% and 59.8%, respectively. Improvement of nutrient digestibility by addition of EM2 was probably due to the beneficial effects of EM2 on fiber hydrolysis and enhanced utilization of the ensiled materials by fermentation micro-organisms. Similar result to this study was reported by (Mulugeta *et. al,* 2015). The improvement in CP content of the treated barley straw in the current study was not sufficient to meet the requirement of ruminal fermentation of ruminants. Hence, need to supplement with additional protein sources to enhance better production and reproduction of animals.

Table 1. Chemical composition, in-vitro organic matter digestibility and estimated metabolizable energy of feeds (Mean ± standard error)

Variables	Untreated barley straw	Treated barley straw	Wheat bran
Dry matter %	93.4	90.09	90.06
Organic matter	92.39	89.93	95.72
Crude protein	2.3	4.9	16.98
NDF	80.05	57.97	38.19
ADF	59.56	40.66	9.39
ADL	11.05	8.03	2.52
IVOMD (%)	33.1	51.7	77.7
EME(MJ/kg)	5.29	8.27	11.65

CP= crude protein; ADF=acid detergent fiber; NDF=Neutral detergent fiber; MJ=Mega joule; IVOMD =In vitro organic matter digestibility; EME= Estimated metabolizable energy (0.16*IVOMD)

3.2. Dry matter intake (DMI)

The daily dry matter intake of crossbred cows are presented in table 2. Cows fed EM2 treated barley straws had significantly ($P<0.01$) increased the daily dry matter intake (6.68kg/day) as compared with those cows fed untreated straw (4.64kg/day). Higher intake of treated straw might be related to increase palatability of straw which make liberating free cellulose and thus enhancing their feeding value for ruminants. This was in agreement with the observation reported by Adebabay (2009) in treated rice fed indigenous breed cows. Yulistiani *et al*. (2003) also indicated improvement in dry mater intake of treated straw.

Table 2. Effect of feeding EM treated barley straw supplemented with concentrate on feed intake and milk yield of lactating crossbred dairy cows (Means ±SE)

Variables	**Intervention diet (T1)**	**Control (T2)**	**SE**
Dry matter intake (DMI), kg/day			
Grazing, hour/day	8h	8h	±0.081
EM treated /untreated barley straw	6.68[a]	4.64[b]	±0.152
Concentrates	1.56[a]	1.5[a]	±0.021
Total DMI, kg/day	8.24[a]	6.16[b]	±0.072
% Roughage	81.1[b]	75.8[a]	±0.015
% Concentrate	18.9[a]	24.2[b]	±0.012
Average milk yield, kg/cow/day	4.98[a]	2.65[b]	±0.470
Increase in milk yield, kg/cow/day	2.31	-	

a,b means in the same row for each parameter with different superscripts are significantly different ($P<0.05$); LS-means: Least square means; SE: Standard error

3.4. Milk yield

There was no variation between the two treatments in initial average daily milk yield of experimental cows. Feeding of intervention diet resulted in a significant ($P<0.01$) increase in daily milk yield by 2.31 kg (4.98 vs. 2.67 kg). Similar results also indicated that cows fed treated *teff* straw had significantly higher milk yield than for un-supplemented animals (Dejene *et al*. 2009). This is due to the increased nitrogen content, palatability, digestibility and nutritive value of the straw as a result of EM2 treatment. It has been accepted that intake and exploitation efficiency of crop residues are influenced by the rate of rumen fermentation (Van Soest, 1982) and the balance of nutrients absorbed in the intestines. The amount of daily milk yield/cow/day reported in the current report was lower than the expected amount from crossbred animals. This is due the reason that the experimental animals were on their late lactation stage.

3.5. Financial analysis

The economic feasibility of this study was analyzed using partial budget analysis approaches. The cost of grazing was not considered for both groups while the total cost of production (feeds, EM, labor for treating straw and material including polyethylene sheet used for sealing the treated straw) was considered. According to this analysis cows fed EM2 treated barley straw and wheat bran gave higher net benefit of ETB 61.90/cow/day, while cows fed untreated barley straw and wheat bran earned low net benefit of ETB 39.54/cow/day (Table. 3). The net profit increased from ETB 39.54/cow/day in the control group (T2) to ETB 61.90/cow/day in T1 due to the improvement in milk yield. Hence, this study demonstrated that feeding the intervention diet to crossbred dairy cows increased the net profit for farmers to ETB 22.36/cow/day over the farmers' practice (Table 3).

Table 3. Financial analysis of feeding EM treated barley straw supplemented with concentrates in lactating crossbred dairy cows

Variables	Intervention diet (T1)	Untreated diet (T2)
Milk yield (kg/cow/day)	4.98	2.65
Sale of fresh milk (ETB/cow/day)	79.68	42.4
Total Revenue	79.68	42.4
Cost of molasses (ETB/cow/day)	0.98	0
Cost of EM (ETB/cow/day)	5.48	0
Cost of polyethylene sheet (ETB/cow/day)	0.51	0
Cost of labor (ETB/cow/day)	3	0
Cost wheat bran (ETB/cow/day)	7.80	7.50
Total Variable cost (ETB/cow/day)	17.77	7.50
Fixed cost	0	0
Gross margin(ETB/head/day)	61.91	34.9
Net profit (ETB/cow/day)	61.91	34.9
Net profit over control, ETB	22.36	

NB. ETB = Ethiopian birr;
#cost of concentrate: 5ETB/kg of wheat bran, 1.50 ETB/kg of molasses, 3 ETB/kg of salt, labor cost (man day) was 35 ETB while cost of polyethylene sheet per meter was 18 ETB
"Selling price of milk was 16 ETB/kg of milk, $1 USD~ 27 ETB

Participants observed that besides increase in milk production, most of the cows in intervention diet showed symptoms of heat at the proper time in contrast to the cows in T2. Considering the positive long-term impact of the intervention diet on production, reproduction, body condition and general health of the animals, the economic returns may be higher by using the intervention diet. Furthermore, considering the cost of production and the market price of milk prevailed in the area during experimental period, the intervention diet was found to be economical compared to farmers practice.

4. Conclusion

Substantial increase in milk production per animal per day and net benefit derived from the increased milk produced indicated that the use of intervention diet is a sound technology for cross breed dairy animals under small scale farmer's condition. Thus it is possible to substantially improve the productivity of crossbred dairy cows in similar production systems by feeding EM2 treated cereal straw and supplementing with feeds of energy source. However, the extent of improvement might need further investigation. The effect of EM on digestibility of OM or fermentation of fiber should be investigated further. Finally, promotion of effective microbes infrastructure for technology transfer, further refinement of EM treatment technique and ensuring either on-farm or nearby availability of supplies necessary for straw treatment are important elements for ensuring impact of the technology.

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