

Milk Yield and Milk Compositions of Lactating Cows Fed Hay and Concentrate Supplement with/without Cottonseed Cake and/or Bole (Lake Soil)

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ABSTRACT

A study was conducted to investigate milk yield and milk compositions of lactating Holstein Friesian cows fed native hay and a concentrate supplement with/without cottonseed cake and/or bole. Thirty two animals with 524 ± 54 kg average body weight were blocked by their expected due dates of calving. Soon after calving each animal was assigned in a randomized complete block design to one of the four dietary treatments of concentrate alone (C) (control), 45% of the the concentrate by weight replaced with cottonseed cake (C+CSC), concentrate plus 3% bole (C+bole) and 45% of the concentrate by weight replaced with 45% CSC plus 3% bole (C+CSC+bole). Intake of hay was significantly ($p < 0.05$) different among treatments. Supplements, total dry matter, crude protein and metabolizable energy intake were not significantly ($p > 0.05$) different among treatment groups. Crude protein intake in treatments C, C+CSC and C+CSC+bole were 13.4, 20.6 and 11.5% higher than the estimated daily requirement respectively, while the intake of those in treatment C+bole was nearly at requirement level. Intakes of ME for treatments groups of C, C+CSC, C+bole and C+CSC+bole were 4.4, 10.3, 9.6 and 13% lower than the estimated daily requirement respectively. There were no significant ($p > 0.05$) milk yield differences among treatments. However, animals fed the treatment diets of C+CSC, CSC+Bole and C+CSC+Bole produced 7.4, 16.3 and 18.2% higher actual milk and 14.3, 24.2 and 25.7% higher 4% fat corrected milk than the control group respectively. Milk fat content was significantly ($p < 0.05$) different among treatments. But milk fat yield, milk protein contents and yield were not significantly ($p > 0.05$) differed among treatments. Lower milk protein contents were observed throughout the treatment groups than expected might be due to low non structural carbohydrate contents of the diets. Supplementing a concentrated diet with 3% bole alone was found biologically and economically profitable. However, optimum levels of CSC and bole to be included in a concentrate diet have to be assessed further.

Key words: milk yield, milk compositions, cottonseed cake, bole soil, dairy cow

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INTRODUCTION

In Ethiopia small and large-scale dairy farms in the urban and peri-urban centers provides most of the milk volume channeled to cities and towns where demand for milk and milk product is high (Azage and Alemu, 1998). These farms are characterized with different levels of management. Inadequate and unbalanced feed supply are the major technical problem result in low total milk output, reduce milk yield per cow and reduce replacement stock (Staal and Shapiro, 1996; Ahmed *et al.*, 2003). Feeds rich in energy, protein and minerals (mainly calcium and phosphorus) are important for optimum milk production and reproductive efficiency. Milk composition is also influenced significantly by dietary factors (DePeters and Cant, 1992). The sources of dietary crude protein (CP) and energy fed to dairy cows also significantly influence the utilization of N and energy in the rumen and the flow of nutrients to the small intestine (McCarthy *et al.*, 1989). The supply of dietary nutrients reaching the site of absorption from gastro-intestinal tract can be maximized by increasing the quantity and quality of dietary nutrients which can escape ruminal fermentation and pass to the small intestine (Clark and Devis, 1983). Increased rumen undegradable protein (RUP) has inconsistent effects on milk yield and components of milk (Christensen *et al.*, 1993; Cunningham *et al.*, 1996).

Most dairy farmers in Ethiopia heavily rely on mill by products than mixed concentrates. The mix of available concentrate feeds also largely depends on available materials and quantity than the requirement and quality of nutrients. The most commonly used feed resources for dairy animals are natural grass and legume hay, wheat bran and middling and nougseed (*Guizota abyssinica*) cake (Staal and Shapiro, 1996). In addition, cottonseed cake is one of the available oil seed cakes widely used as protein source in the fattening operation. Although, cottonseed cake is considered as a

rumen bypass protein source, it is rarely utilized in commercial dairy farming system in Ethiopia and information on its potential in productive and reproductive performances of dairy cattle is limited. Levels of essential minerals in most commonly used fibrous feed resources in Ethiopia was studied and reported to be deficient (Kabaija and Little, 1989). Solomon (1992) also reported that locally produced oilseed cakes were low in Ca and Na contents. The existing animal feed processing firms include limestone and common salt (NaCl) in concentrate mixture as mineral source depending on availability. A salty, lake soil locally known as bole is also abundantly and cheaply available in the central rift valley lake of Abiyata and used by local farmers as mineral source for their animals. However, documented information on the nutritive value and influences of bole on milk production and milk compositions of dairy cows is scarce. Therefore, this study aimed to evaluate milk yield, milk composition and feed efficiency of lactating dairy cows fed on native grass hay and a concentrate supplement with/without cottonseed cake and/or bole soil.

MATERIALS AND METHODS

This study was conducted at Holeta Dairy Farm belonging to cattle genetic improvement center of Federal Ministry of Agriculture. The farm is located at about 44 km to the West of Addis Ababa, at 9°3'N latitude and 38°30'E longitude. It has an altitude of 2390 meters above sea level and receives an average annual rainfall of about 1700-mm. The rainfall is erratic and bimodal with the main rains occurring from June to September. The minimum and maximum average temperature is 6.3°C and 22.1 °C respectively.

Thirty-two pregnant Holstein Friesian cows with average body weight of 524±54 kg were blocked by their expected due date of calving as early (B1) and late (B2). Soon after calving

animals were assigned in a randomized complete block design to one of the four dietary treatments of concentrate alone (C) (control), 45% of the concentrate diet by weight substituted with cottonseed cake (C+CSC), concentrate plus 3% bole (lake soil) (C+Bole) and 45% of the concentrate substituted with cottonseed cake plus 3% bole (C+CSC+Bole). Data on milk yield and feed intake were collected on daily basis starting from day one postpartum for 135 days. The compositions of the commercially formulated concentrated diet (control) were wheat bran (55%), wheat middling (10%), nougseed (*Guizota abyssinica*) cake (30%), limestone (3%) and common salt (2%). The CSC used in this trial was from mechanical oil extracting factory. The animals were individually penned and fed with *ad libitum* mixture of native grass and legume hay dominantly composed of *Digitaria decumbens*, *Eragrostis pilosa*, *Trifolium repens* and *Trifolium prantense* species. The experimental diets were offered at the rate of 0.5 kg per kg of milk yield in two equal feedings before the morning and evening milking. Water was offered three times daily in the morning, noon and evening. The animals were hand milked twice daily at 6 to 7 AM and 4 to 5 PM and daily milk yield was recorded accordingly. Data for feed intake and refusals were recorded on daily basis. Feed samples were collected weekly, bulked, sub-sampled and delivered to International Livestock Research Institute (ILRI) laboratory for chemical analysis. Milk samples from individual animal were collected twice during the last week of the experiment (week 18 postpartum) and delivered to laboratory for milk fat, protein and total solid analysis. Costs of supplemental feeds per kg of milk yield for each treatment groups were estimated based on the market prices of the mixed concentrate, cottonseed cake and bole. The concentration of non structural carbohydrate (NSC) in each dietary treatment was estimated as, $NSC = 100 - (\%CP + \%NDF + \%EE + \%Ash)$ according to NRC (2001).

Chemical analysis

Feeds were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and ash using standard procedures of AOAC (1990). Neutral detergent fiber (NDF) was determined using the method described by Van Soest and Robertson (1985). The *in vitro* organic matter digestibility (IVDOMD) was determined using the procedures of Tilley and Terry (1963). Metabolizable energy (ME) contents of the feeds was estimated from *in vitro* digestibility (IVDOM (g/kg DM) x 0.016) as suggested by Barber *et al.* (1984). Calcium (Ca), sodium (Na), potassium (K), magnesium (Mg) and manganese (Mn) contents of the feeds were analyzed using atomic absorption spectrophotometers according to Perkins (1982), and phosphorus (P) content was determined using auto analyzer according to AOAC (1990). The intakes of nutrients were estimated by multiplying dry matter intake (DMI) of the feeds with the values of their respective nutrient concentration according to Kearl (1982) and MAFF (1985). The compositions of milk fat and milk protein were analyzed using Gerber method and formaldehyde titration respectively and total solid was determined by oven drying the milk sample according to O'Mahoney (1988).

Statistical analysis

Data were analyzed using general linear model (GLM) procedure of SAS (1999). Differences between treatment groups on intake of feeds and nutrients, milk yield and milk composition were evaluated using Duncan multiple range test. The model used to analyze the treatment effects on milk yield and milk composition was:

$$Y = \mu + b_i + t_j + e_{ij}$$

Where, Y = means for response variables

μ = overall mean

b = effects of i^{th} block (b = 1, 2)

t = effects of j^{th} treatment (t = 1, 2, ...4)

e = error term

RESULTS AND DISCUSSION

Chemical compositions of experimental feeds

Chemical compositions of the grass hay and the experimental diets are presented in Table 1. The grass hay was deficient in CP content and high in NDF content as expected. It was also deficient in Ca, P, Na, Mg and Mn contents and this was consistent with the report of Vijchulata (1998) for different species of grasses in Thailand. The concentrations of CP for the concentrate mixtures of all treatment groups were sufficient for lactating cows. The NDF content of the concentrate diets was slightly higher for treatments consisting cottonseed cake C+CSC and C+CSC +Bole. Dietary concentrations of Ca in the concentrate mixtures of control, and control plus bole and control plus CSC with bole treatments were sufficiently higher than the requirement level suggested by McDowell (1997). The concentrations of P, Na, K, Mg and Mn contents of the concentrate mixtures were sufficiently higher than the requirements throughout the treatments. Since Ca content of cottonseed cake was lower (0.21 %DM) its inclusion in the treatment diets of C+CSC and C+CSC+bole depressed Ca contents of these diets. Sodium contents of C+bole and C+CSC+bole was higher than that of C and C+CSC which might be due to the inclusion of bole soil which had higher concentration of Na. All treatment diets were almost similar in the contents of P, K and Mg.

Crude protein content of cottonseed cake used in this study was lower than the expected value of above 36%, and it was similar to the value for whole cottonseed reported elsewhere (Smith *et al.*, 1981; NRC, 1989), which might be due to mechanical methods used for oil extraction.

Feeds and nutrients intake

Means of feeds and nutrient intake of lactating cows fed the hay and concentrate supplement with/without cottonseed cake and/or

Table 1 Mean chemical compositions of the experimental diets for cows fed hay and concentrated diet supplemented with cottonseed cake and/or bole.

Experimental diets	(%DM)										(mg/kg)		
	DM%	OM	CP	NDF	EE	Ash	IVDOM	Ca	P	Na	K	Mg	Mn
Hay	91	92	4.9	72	1.17	8.35	46.3	0.40	0.17	0.02	1.48	0.17	340
Conc. (control)	89	89	20.1	39	5.07	10.96	669	1.57	0.88	0.48	1.09	0.41	147
Conc. + CSC ^a	90	92	21.9	46	6.18	8.47	625	0.74	0.82	0.39	1.22	0.38	82
Conc. + Bole ^b	90	84	20.2	32	4.31	15.94	665	1.69	0.83	1.39	1.03	0.39	151
Conc. + CSC + Bole	91	88	21.9	47	5.70	11.83	630	0.79	0.77	0.88	1.16	0.38	98
CSC alone	95	94	24.9	48	7.8	5.6	557	0.21	0.86	0.02	1.33	0.35	8.8
Bole (lake soil)	-	-	-	-	-	-	-	0.21	0.04	36.84	1.13	0.08	11
Minerals requirements ^c	-	-	-	-	-	-	-	0.48 – 0.77	0.25 – 0.48	0.06 – 0.25	0.80 – 1.20	0.19 – 0.30	40 – 100

^a CSC=cotton seed cake; conc. = concentrate.

^b Bole = a salty lake soil used by local farmers as mineral source.

^c Adapted from McDowell (1997).

bole are presented in Table 2. Daily intakes of hay was significantly different ($p<0.05$) among treatments. There were 3.42, 10.43 and 13% higher intake of grass hay for animals supplemented concentrated diet with cottonseed cake (C+CSC), bole (C+Bole) and combination of cottonseed cake and bole (C+CSC+Bole) respectively. The intake of hay was depressed in animals fed a concentrated diet with cottonseed cake alone. This was consistent with the report of Wanapat *et al.* (1996) in which the intake of rice straw was depressed with increased level of cottonseed meal above 4 kg/d/head in dairy cattle. The intakes of supplement, total DM, CP and ME were not significantly ($p>0.05$) different among treatments. However, there were relatively higher intakes of supplement, total DM, CP and ME by animals fed on concentrated diet with CSC and/or bole than the control group. Daily CP intake of animals in treatments C, C+CSC and C+CSC+Bole were

13.4, 20.6, and 11.5% higher respectively than the estimated daily requirements, while the intake of those in treatment of C+Bole was nearly at requirement level. Daily intake of ME for animals in treatments C, C+CSC, C+Bole and C+CSC+Bole were 4.4, 10.3, 9.6 and 13% respectively lower than the estimated daily requirement (Table 2). The intakes of NDF and EE and the concentration of NSC were significantly ($p<0.001$) different among treatments (Table 2). In addition, the levels of NSC in all treatment groups were below the recommended range of 30 to 46% (Nocek and Russell, 1988).

Milk yield, milk composition and milk production efficiency

Daily actual milk yield, fat corrected milk yield, milk composition and milk production efficiency of cows fed on native hay and a concentrate supplement with/without CSC and/or

Table 2 Means of feeds and nutrient intake of lactating cows fed hay and a concentrated diet supplemented with cottonseed cake and/or bole.

Parameters	Treatments ^d				SE	P
	C	C+CSC	C+Bole	C+CSC+Bole		
Hay intake (kg/d)	5.85 ^c	6.05 ^{bc}	6.46 ^{ab}	6.61 ^a	0.18	*
Supplement intake (kg/d)	8.25	8.60	8.84	9.07	0.55	NS
Total dry matter intake (kg/d)	14.10	14.65	15.30	15.68	0.62	NS
Total CP intake (g/d)	1944	2179	2103	2300	188.51	NS
CP Requirement (g/d) ^x	1715	1807	2021	2205	117.90	
CP (% DMI)	13.67 ^b	14.75 ^a	13.70 ^b	14.58 ^a	0.27	**
ME intake (MJ/d)	132	131	142	140	6.16	NS
ME Requirement (MJ/d) ^y	138	146	157	161	7.60	
ME (MJ/Kg DMI)	9.3	8.9	9.3	8.9	0.05	NS
Total NDF (%DMI)	53 ^b	57 ^{ab}	49 ^c	58 ^a	0.52	**
Hay NDF (% total NDFI)	57.2 ^b	53.6 ^b	62.3 ^a	54.8 ^b	1.69	***
Total EE (%DMI)	3.4 ^c	4.05 ^a	2.90 ^d	3.8 ^b	0.08	***
Non structural carbohydrate (%DMI)	20.3 ^a	15.9 ^b	22.3 ^a	14.5 ^b	0.93	***

^d C = concentrate; CSC = Cottonseed cake

^{x, y} CP (g/d/head) and ME (MJ/d/head) requirements were estimated based on average body weights and actual milk yields of individual animal in each treatment group;

* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$; NS=not significant

^{a, b}, means with different superscripts in a row are significantly different ($p<0.05$)

bole are presented in Table 3. Daily actual milk yield and FC milk yield were not significantly ($p>0.05$) different among treatments. However, higher daily yields of milk and FC milk were recorded in the supplemented groups than in the control group. Animals in the treatment groups of C+CSC, C+Bole and C+CSC+Bole produced 7.4, 16.3 and 18.2% respectively higher actual milk and 14.3, 24.2 and 25.7% respectively higher 4% fat corrected milk than the control group. The lower milk productivity of animals fed on the concentrate diet with CSC alone might be due to relatively lower intake of grass hay and supplement and consequently lower total DM intake (DMI). This explained that productivity of ruminants was influenced primarily by feed intake, which in turn was determined by the digestibility and capacity of the diet to supply the correct balance of nutrients required (Preston and Leng, 1987). Although statistically not significant ($p>0.05$), the 7.4% and 14.3% increase of actual and FC milk yield respectively in animals fed a concentrate diet with CSC alone was partly consistent with the report of Smith *et al.* (1981) which revealed that substitution of total mixed ration with different levels of whole cottonseed did not significantly affect DMI or milk yield of Holstein Friesian cows, but increased milk fat and FC milk yield. Wanapat *et al.* (1996) also reported that supplementing low protein basal diet of rice straw and cassava chips with different levels of cottonseed meal (2, 3, 4 and 5 kg/d/head) in crossbred Holstein-Zebu cows linearly decreased straw intake, but increased the production of milk up to 4 kg/d/head of cottonseed meal. But milk yield was depressed with 5 kg/d/head.

Animals fed a concentrated diet supplemented with bole alone or the combination of bole with CSC respectively produced about 7.6 and 9.1% more milk than those fed on concentrate diet supplemented with CSC alone, which might be due to the relatively higher Na and K content of the soil. Sanchez *et al.* (1994a, b) and Berger

(1994) reported that dietary Na intake above those needed to meet requirements improved DM intake and milk yield in lactating cows. Sanchez *et al.* (1994a, b) also reported that DM intake and milk yield response of mid-lactation dairy cows over a range of dietary K concentration of 0.66 to 1.96 (%DMI) were curvilinear, with the maximum performance when diets contained 1.50% K. In addition, as soils are usually considered to influence animal nutrition through the quantity and quality of herbage they produce, there was also direct soil-animal effect (McDowell, 1985). Ingested soil provides a source of essential elements, and improves the utilization of energy and increases the availability of certain minerals (Miller *et al.*, 1978). Inclusion of soil in the diet of ruminants reduces fecal losses of Ca and Mg and increases apparent availability of both. It was also suggested by Miller *et al.* (1978) that there might be some physiochemical processes induced by soil itself, since the increased apparent absorption and retention of Ca and Mg could not be attributed directly to the contents of these elements in the soil.

Lactation curves over 18 weeks of lactation for animals fed on hay and concentrate supplement with/without CSC and/or bole are presented in Figure 1. Animals fed on concentrate alone (control) had slower increase of milk yield up to the peak of 17.7kg at week 7, while those fed on a concentrate diet with CSC had relatively faster and sharp increase, but attained peak yield of 18.3 kg shortly at week 5. The treatment group fed on a concentrate with bole had faster and sharp increase until week 5, from where the trend of increase became slow until the peak yield of 20 kg at week 8. Similarly, the group supplemented with the combination of CSC and bole had faster increase until week 5 and then after became slow until the peak yield of 19.2 kg at week 7. Despite the shorter and lower peak yield, the trend of decline after peak yield at week 7 for this group was almost flatter as compared to other groups.

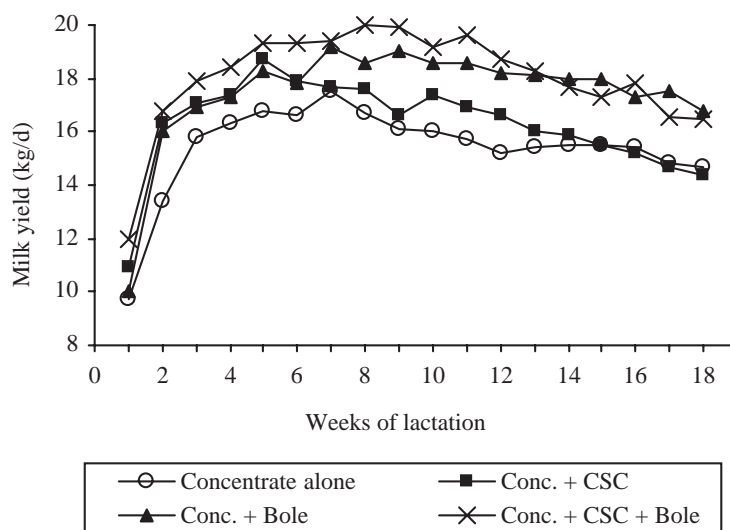


Figure 1 Weekly milk yield of cows fed hay and concentrate supplement with/without cottonseed cake and/or bole.

There was significant ($p < 0.05$) treatment effects on milk fat content, but daily milk fat yield was not significantly ($p > 0.05$) affected by treatments. Inclusion of CSC, bole or the combination of CSC and bole increased more milk fat content by about 11.1%, 12.5% and 11.1% respectively; and daily fat yield by 9.2%, 19.1% and 20.1% respectively than the control diet. Inclusion of CSC and/or bole equally increased milk fat content. The reason for the increase in milk fat content and yield with the inclusion of bole was not clear. Probably bole soil might have a buffering effect on the rumen environment which resulted in the decreased ruminal propionic acid production and increase the ratio of acetic acid to propionic acid in favor of milk fat yield (Rogers *et al.*, 1982). Rogers and Davis (1982a) reported that the improvement in animal performances when high concentrated diets were supplemented with mineral salts like sodium bicarbonate (NaHCO_3) might be attributed to increased pH which enhanced ruminal fermentation and increase rumen fluid outflow. However, the buffering effects of bole on the rumen environment need further assessment.

There was no significant ($p > 0.05$) treatment effects on milk protein content and yield. Generally, milk protein content throughout the treatments groups in this study was lower than expected. Substituting a concentrate diet with CSC did not affect the content and yield of milk protein in this study. The efficiency of milk protein production was not significant among treatments and also lower than the values reported by other workers (Arieli *et al.*, 2004). This might be due to lower ME supply of the diets than the estimated level of requirement (Table 2). Energy intake either through concentrate or roughage ingredients had significant influence on the percentage and yield of milk protein (DePeters and Cant, 1992). Coulon and Rémond (1991) reported that milk protein content increased linearly with energy supply, except from fat addition (Emery, 1978; Macleod *et al.*, 1983; Grieve *et al.*, 1986). In this study the dietary ME intake was lower than the estimated requirement, while CP intake was higher than requirement. Therefore, the results of milk protein content and yield in this study was in line with the reports of Gordon and Forbes (1970) in which milk protein tended to increase with increasing energy

intake with a low protein diet but not with a high protein diet. The declining tendency of milk protein efficiency with the surplus CP supply in our study (Table 3) also agreed with the findings of Arieli *et al.* (2004) in which milk protein production efficiency tended to increase from 0.29 in the high protein (HP) diet to 0.31 in the low protein (LP) diet. However, in their study the energy supply was adequate to support higher milk protein yield. Milk protein content and yield could also be increased by improving the profile of amino acid in microbial protein, by reducing the amount of surplus protein in the diet, and by increasing the amount of fermentable carbohydrate in the diet.

In addition, the low concentration of NSC in all dietary treatments (Table 2) might be contributed to the lower milk protein content. Non structural carbohydrate rapidly and completely ferments in the rumen and increases the energy densities of the diets, which improves the energy supply and determine the amount of bacterial protein (BP) produced in the rumen. Milk protein concentration can be lower with reduced BP supply

caused by lack of ruminally fermented energy (NRC, 2001). In another study, the percentage and yield of milk protein increased when NSC in the dietary DM increased from 41.7 to 46.5 percent (Minor *et al.*, 1998). Ruminally synthesized BP is the major source of essential amino acids to be supplied to the lower digestive tract. Since milk protein content also depends on the supply of essential amino acids, lysine and methionine in particular (Rulquin *et al.*, 1993), limitations in supply of bacterial crude protein consequently limit milk protein content of dairy cows (NRC, 1989). Inadequate energy intake and feeding of highly degradable protein in early lactation can produce excess ammonia, high blood and milk urea concentration in the rumen, but the concentration of milk protein low (Emery, 1978). Total solid content of milk was not significantly ($p>0.05$) affected by treatments in this study.

Daily milk yield per kilogram supplement and per kilogram DM intake were not significantly ($p>0.05$) different between treatments. However, relatively higher milk yield per kilogram supplement intake and DMI was

Table 3 Means milk yield, milk composition and efficiency of feed utilization by lactating cows fed hay and concentrated diet supplemented with cottonseed cake and/or bole.

Parameters	Treatments				SE	p
	C	C+CSC	C+Bole	C+CSC+bole		
Milk yield (kg/d)	15.19	16.32	17.66	17.95	1.26	NS
FC milk yield (kg/d)	13.97	15.97	17.35	17.56	1.31	NS
Fat (%)	3.43 ^b	3.81 ^a	3.86 ^a	3.81 ^a	0.11	*
Fat yield (kg/d)	0.526 ^b	0.629 ^a	0.686 ^a	0.692 ^a	0.06	*
Protein (%)	2.48	2.50	2.54	2.45	0.07	NS
Protein yield (g/d)	0.378	0.412	0.451	0.437	0.04	NS
Protein yield (%CP intake)	18.96	18.87	21.32	19.00	1.26	NS
Total solid (%)	11.00	11.20	11.44	11.44	0.28	NS
Kg milk/kg supplement	1.91 ^b	1.88 ^b	2.11 ^a	2.05 ^a	0.10	*
Kg milk/ DM intake	1.10	1.09	1.21	1.18	0.06	NS
Supplement cost/kg milk (Birr) ^c	0.58 ^a	0.56 ^a	0.49 ^b	0.55 ^a	0.02	*

* = $p<0.05$; NS=not significant; FC = fat corrected; C= concentrarate; CSC = Cottonseed cake

^c 1USD=8.68 Ethiopian Birr

^{a, b} means with the different superscripts in the same row are significantly different ($p<0.05$)

observed for animals supplemented with bole alone. There was significant ($p < 0.01$) treatment effect in costs of supplement per kilogram of daily milk yield (Table 3). There was lower cost of supplement for animals fed on concentrated diet supplemented with bole alone followed by group supplemented the combination of CSC and bole. The costs of feeding either concentrate alone, or supplemented with CSC and/or bole were not significantly ($p > 0.05$) differed. Inclusion of bole soil alone can reduce the cost of milk production through increased productivity.

CONCLUSION

Although it was statistically non significant, feeding a concentrate diet substituted with 45% cottonseed cake with bole soil substantially improved both actual and fat corrected milk yields, and milk fat content. But it was biologically and economically less attractive than utilizing bole soil alone. Supplementing a concentrate diet with 3% bole alone was found biologically and economically profitable. However, optimum levels of CSC and bole to be included in a concentrate diet have to be assessed further.

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