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Effects of sources of dietary protein supplemented to oat-vetch hay mixture on milk yield and milk composition of crossbred dairy cows

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The experiment was conducted in Debre Zeit Agricultural Research Center with the objective of evaluating the effects of sources of dietary protein supplemented to oat-vetch mixture hay on milk yield, milk composition and profitability in lactating crossbred dairy cows. Four high grade cross bred (Holstein Friesian × Boran) dairy cows with similar lactation stage (mid lactation) and parity were used. The experimental diets were T1 (ad libitum oat-vetch hay + noug seed cake), T2 (ad libitum oat-vetch hay + cottonseed cake), T3 (ad libitum oat-vetch hay + linseed cake) and T4 (ad libitum oat-vetch hay + mixture of the three oil seed cakes). A 4 × 4 Latin square design was used for the feeding experiment with four dietary treatments assigned to animals at random initially. The animals were offered hay at a rate sufficient to allow for a 20% refusal and the amount of concentrate offered was at 0.5 kg/l of milk in all treatments. The concentrate mix consisted of 33% oil seed cakes (OSC), 66% wheat bran and 1% salt. Treatment effects on milk yield, milk fat, milk protein, lactose and total solids were significantly different (P<0.05). Economic analysis showed that T2 based supplementation was feasible than the remaining dietary treatments. Therefore, it can be concluded that T2 can optimize both biological and economic response of dairy cows.

Key words: Cottonseed cake, dairy cow, linseed cake, milk, noug seed cake, oat-vetch, wheat bran.

INTRODUCTION

Ethiopia's stricken economy is based on subsistence agriculture accounting for almost half of the gross domestic product (GDP), 60% of exports, and 80% of total employment (Exxun, 2008). The sub-sector also accounts for 19% to the export earnings (BoFED, 2006). Livestock production contributes 30 to 35% of the GDP and more than 85% of farm cash income. In this respect, milk production is playing a vital role in the livelihoods of the people of Ethiopia.

Inadequate and unbalanced feed supplies are the major

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Table 1. Experimental treatments.

Treatment	Treatments description	Supplements feeding level (kg/L of milk/day)
Treatment 1 (T_1)	*Ad* O-V + NSC (33 %) + WB(66%) + salt (1%)	0.5
Treatment 2 (T_2)	*Ad* O-V + CSC (33%) + WB (66%) + salt (1%)	0.5
Treatment 3 (T_3)	*Ad* O-V + LSC (33%) + WB (66%) + salt (1%)	0.5
Treatment 4 (T_4)	*Ad* O-V + NSC (11%) + CSC (11%) + LSC + (11%) + WB (66%) + salt (1%)	0.5

Ad O-V = *Ad-libitum* oat-vetch hay; NSC = Noug seed Cake; LSC = Linseed Cake; CSC = Cottonseed Cake; WB = wheat bran; d = day.

technical problem that results in low total milk output, reduced milk yield per cow and reduced replacement stock (Ahmed et al., 2003). Feeds rich in energy, protein, and minerals are important for optimum milk production and reproductive efficiency. Milk composition is also influenced significantly by dietary factors (De Peters, 1992). However, cattle are predominantly fed on natural pastures and crop residues. Thus, due to the scarcity as well as poor quality of feeds available, the productivity of crossbred animals is very low. In order to exploit the production capacity, the crossbreds require not only more feed, but also feeds of better quality. If these facts are not taken into consideration properly, the cross bred dairy animals will suffer from under feeding and they will also produce below their capacity (Mohamed et al., 2010).

Most dairy farmers in Ethiopia heavily rely on agro-industrial byproducts than mixed concentrates. The mix of available concentrate feeds also largely depends on the availability of the materials and quantity than the quality of nutrients and animal requirement. The most commonly used feed resources for dairy animals are natural grass and legume hay, wheat bran and middling, and noug seed (*Guizota abyssinica*) cake (Staal and Shapiro, 1996). Although cottonseed cake is one of the available oil seed cakes widely used as protein source in Ethiopia, it is rarely utilized in commercial dairy farming system as compared to fattening operation. Hence, information on its potential in improving productive and reproductive performances of dairy cattle is limited. Nevertheless, there is a considerable interest in protein sources that are slowly degraded in the rumen. These relatively resistant protein sources can have special value for lactating cows and for young growing ruminants whose protein requirements are relatively high (Tamminga, 1979).

In response to this, empirical analysis of the adoption of forage in dairy farms in mixed farming systems has taken place in Debre Zeit area where forage technology has been introduced in association with improved dairy production. The empirical results suggest that the potential for adoption of improved forage is high where both livestock productivity and response to improved feed technology are high, as with crossbred cows and where production is more market-oriented, as with dairy (Mohamed et al., 2010). However, little work has been done on determining the level and type of supplementation to be used with improved forages such as oat-vetch mixture hay in a way it optimizes the performance and profitability of dairy production. Therefore, the objective of this study was evaluating the effects of sources of dietary protein supplemented to oat-vetch mixture hay on milk yield, milk composition and economic feasibility in lactating crossbred dairy cows.

MATERIALS AND METHODS

The study area

The study was conducted in Debre Zeit Agricultural Research Center (DZARC), which is located 45 km south east from Addis Ababa. The area has an altitude of about 1900 m.a.s.l. The maximum and minimum temperature received is 24.3 and 8.9°C, respectively and the mean annual rainfall of the area is 851 mm.

Experimental animals

Four lactating crossbred cows (Boran × Holstein Friesian) with similar lactation stage (mid lactation) and different parities (third, fourth, fifth and sixth) were used. The cows were for a period of 112 days, that is, four periods of 28 days each. The first 14 days of each period involved the adaptation of the animals to the treatment diets. Measurements and data collection were conducted during the remaining 14 days of each period. The cows were fed and watered individually. Milking was conducted by hand twice per day at 6:00 am in the morning and at 3:00 pm in the evening.

Experimental diets

The basal feed used for the experiment was oat-vetch mixture hay. The animals were supplemented with concentrate feed, composed of noug seed cake, linseed cake and cottonseed cake separately mixed with wheat bran at a ratio of 33:66 oil seed cakes to wheat bran and 1% salt across the treatment. The concentrate mixtures were based on the requirement for major nutrients of lactating crossbred cows with milk yield of 8 to 10 L/day and a butter fat content of 4.5% as recommended by ARC (1990) when fed at the rate of 0.5 kg/l of milk. The hay was offered at a rate sufficient to allow for a 20% refusal (Table 1).

Experimental design

A 4 × 4 Latin square design was used for the feeding experiment with four dietary treatments assigned to each animal, but one dietary treatment per period. The dairy cows were adapted to each of the diet for a period of 14 days that is between each period, followed by a period of 14 days of data collection.

Milk yield and milk composition

Individual cow milk samples from morning and evening for seven days of the experiment were taken and placed in a clean plastic cup, after placing it in icebox and taken to laboratory for milk composition analysis. The milk samples were analyzed for fat, protein, total solids, and lactose contents. Lactoscan® (Page and Pedersen, international Ltd USA, 2004) instrument was used for milk composition analysis.

Partial budget analysis

A simple partial budget analysis was conducted on the basis of calculation of the total cost of supplement feeds [cottonseed cake (CSC), Noug seed (*Gizotia abyssinica*) cake (NSC) and linseed cake (LSC)] and basal diet (oat- vetch), and considering milk sales price and labor cost during the experimental period gained from the result (Upton, 1979). The milk price was fixed based on the market price of milk. The prices of the supplements and oat-vetch for treatment were obtained from the current market price during the experimental period. In the analysis, the total return (TR) was determined by the difference between milk selling and feed cost in each treatment across the four period. The net income (NI) was calculated by subtracting total variable cost (TVC) from the total return (TR).

NI = TR-TVC

The change in net income (NI) was calculated as the difference between the change in total return (TR) and the change in the total variable cost (TVC):

$\Delta NI = \Delta TR - \Delta TVC$

The marginal rate of return (MRR) measures the increase in net income (NI) associated with each additional unit of expenditure (TVC).

Statistical analysis

Collected data from milk yield and compositions, live weight changes, apparent digestibility, voluntary dry matter (DM) and nutrient intakes were coded as deemed necessary and entered into the Microsoft excel program and summarized. Data analysis was carried out using the mixed procedure of SAS (2004). Treatment means were computed using the LSMEANS option and separated using comparisons of least squares mean. The following model was used to analyze the effect of supplementation of oil seed cakes on feed intake, apparent digestibility, body weight change, milk yield, and milk composition.

$Y_{ijkl} = \mu + C_i + P_j + T_k + e_{ijkl,}$

Where, Y_{ijkl} = response from i^{th} cow, during p^{th} period to k^{th} treatment; μ = population mean; C_i= i^{th} cow effect (i= 1, 2, 3, 4); P_j = j^{th} period effect (j=1, 2, 3, 4); T_k = t^{th}treatment effect (k = 1, 2, 3, 4) and
e_{ijkl} = Residual error.

RESULTS AND DISCUSSION

Body weight change of cows

The effect of dietary treatments on body weight change was significantly ($p<0.05$) different. Linseed cake based supplement resulted in the highest (4.25 kg) followed by cotton seed cake (3.25 kg) and T4 (3.00kg) based supplement. There was no weight loss across the whole treatments. The absence of weight loss during all periods indicate that all the supplements together with the basal diet provided sufficient nutrient to the animal above the maintenance requirement (Table 2).

Cows on all dietary treatments in the present study have a positive change in body weight. The positive weight change across the all treatments is attributed to the fact that supplementing cows with different types of oil seed cake with wheat bran do not have any negative effect on body weight change.

The highest ($p<0.05$) body weight change was observed when linseed cake was supplemented to the animals. This might be attributed to the fact that linseed cake produce rapid gain and excellent finish and it is more useful for fattening animals than dairy animals (Adugna, 2008). Similarly, cows supplemented with cottonseed based concentrate showed the second highest weight gain, this is because of the fact that cotton seed cake is also an excellent protein supplement for fattening animals and is practically equal to linseed meal for fattening in addition to increasing milk yield and milk composition.

Milk yield and composition

The highest (7.97 kg) milk yield was obtained from cows supplemented with cottonseed cake (T2) followed by the group supplemented with (T4) mixtures of the three oil seed cakes (7.17 kg). Similarly, there were significant ($p<0.05$) treatment effects on milk fat, milk protein, lactose and total solids ($p<0.01$). Cows fed T2 diet showed relatively the highest (4.44%) milk fat content followed by T4 (4.32%) and T1 (4.16) whereas the least (3.95%) was recorded for those cows fed diet T3. Similarly, cows fed T4 diet produced 0.955, 0.564 and 0.28% more lactose than T3, T2, and T1 supplement diet consumed cows, respectively.

The mean daily milk yield (6.95 kg/day) from the present trial was almost similar to the value of 6.66 kg/day reported by Khalilli et al. (1992) for crossbred cows fed a basal diet of oat-vetch hay supplemented with a concentrate at the rate of 2.5 kg/day. Likewise, the mean daily milk yield of 6.95 kg/day from the present trial is also comparable to the value of 6.2 kg/day milk yield reported by Varvikko and Khalilli et al. (1993) for crossbred cows fed a basal diet of oats-tagasaste forage supplemented with a concentrate at the rate of 2.5 kg/day (Table 3).

Cow milk production and milk composition are governed by nutritional values of feeds. Quality protein supplement based on protein requirements of cows for maintenance and milk production, improve milk production due to the effects on feed digestibility and dry

Table 2. Average body weight change of dairy cows fed with different experimental diets over the experimental period.

Treatment	Number of cows	Live weight change (kg/cow)
T1	4	2.50[b]
T2	4	3.25[ab]
T3	4	4.25[a]
T4	4	3.00[b]
Mean		3.25
SL		*
SEM		0.33

[ab]Means with different superscripts within column are significantly different ($p < 0.05$).

Table 3. Milk yield and composition of dairy cows fed with different experimental diets.

Treatment	Milk yield (kg/d)	Milk composition			
		Fat (%)	Protein (%)	Lactose (%)	TS (%)
T1	6.47[b]	4.16[bc]	2.91[a]	4.16[b]	12.32[b]
T2	7.97[a]	4.44[a]	2.94[a]	4.18[b]	12.72[a]
T3	6.17[bc]	3.95[c]	2.82[b]	4.03[b]	11.62[c]
T4	7.17[ab]	4.32[ab]	2.92[a]	4.35[a]	12.30[b]
Mean	6.95	4.22	2.89	4.18	12.24
SL	*	*	*	*	**
SEM	0.39	0.08	0.02	0.05	0.02

[abc]Means with different superscripts within column are significantly different ($p<0.05$).

matter intake. Toolsee and Boodoo (2002) noted 11 to 30% increases in milk production when cows were supplemented with a ration containing CSC at a percentage of 33% which is in line with the present study.

The mean values of lactose (4.18%) and total solids (12.24%) can fairly be compared with values of 4.10 and 12.66% reported by Zelalem (1999) in cross dairy cows fed hay supplemented with concentrate. Similar to the present study, Petit (2010) reported that feeding diets with whole or crushed or micronized linseed had significant effect on the milk protein content in dairy cows during mid-lactation. The mean milk protein content (2.89%) in the present study was in line with the value (2.81%) reported by Adebabay (2009) in local cows fed treated wheat straw supplemented with noug seed cake. Similarly, Hayaz et al. (2013) reported 2.77±0.09% milk protein from cows fed 35% of CSC in a ration which was almost similar to the current study. Milk protein content throughout the four treatment groups in this study was lower than the expected. The lower percentage of milk protein in the present study can be attributed to the total mix ration intake or may be due to usual inverse relationship between milk and the content of milk solid components (Olafadehan, 2008). According to Klusmeyer et al. (1990) milk protein content depress with increased in forage intake. Likewise, Looper (1997) noted that dietary manipulation results in milk protein concentration changing approximately 0.60 percentage units. However, 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.

The present result showed that supplementing animals with cottonseed cake had significantly higher milk fat content as compared to other oil seed cakes. Therefore, cottonseed cake is an excellent oil seed cake used to improve milk production and milk composition constituents in lactating dairy cows. Similar to the present study, James et al. (2010) had concluded from his study that supplementation of CSC has significantly ($P < 0.05$) increased the milk fat content. In general feeding supplement based on CSC to smallholder subsistence dairy cows may have an advantage since the system is based on sale of butter fat than liquid milk. However, this could be also of value in countries where milk sale is based on fat percent.

Partial budget analysis

The effects of feeding different oil seed cakes (NSC, CSC and LSC) as protein sources and oat-vetch hay on net

Table 4. Profitability of milk production from cows fed with concentrate mix based on different oil seed cakes.

Parameter	Treatment			
	T1	T2	T3	T4
O-V hay consumed (Kg/cow)	481.00	493.92	474.88	474.32
Concentrate consumed (Kg/ cow)	181.44	222.32	173.6	192.64
Total feed consumed(Kg/cow)	662.44	716.24	648.48	666.96
Milk yield (kg/cow/d)	6.47	7.97	6.17	7.17
TVC/treatment (birr)	3818.79	3927.26	3950.17	3893.73
Gross income (ETB)	4347.84	5355.84	4146.24	4818.24
Net return (net income)	529.05	1428.58	196.07	924.51
Change in total return (TR)		1008	-201.6	470.4
Change in net income (∆NI)		-899.53	-332.98	395.46
Change in total variable cost (∆TVC)	-	108.5	131.38	74.94

1 kg NSC =4 ETB, 1 kg CSC = 4.5 ETB, 1 kg LSC = 8 ETB, 1 kgWB = 2.5 ETB, 1 kg Oat-vetch = 2.5 ETB, T1 = NSC + WB + ad libitum oat-vetch mixture hay; T2 = CSC + WB + ad libitum oat-vetch mixture hay; T3 = LSC + WB + ad libitum oat-vetch mixture hay; T4 = NSC + CSC+ LSC + WB + ad libitum oat-vetch mixture hay; ∆TVC = change in total variable cost; ∆NI = change in net income; MRR = marginal rate of return.

return (NR) and marginal rate of return (MRR) are presented in Table 4. The result obtained from partial budget analysis indicated that cottonseed cake supplementation (T2) has higher net return followed by T4, T1 and T3 respectively. The lowest net return was obtained from cows supplemented with linseed cake (T3) supplementation. Although there were some variations in net return, there was no loss.

The variation in net return between treatments occurred due to price difference between the three oil seed cakes, the amount of total feed intake per treatments and total milk yield per treatment. The result showed that the net return in the present study was, 1428.58 (T2), 924.51(T4), 529.05(T1) and 196.07(T3) ETB, indicating that the net return order was T2 > T4 > T1 > T3. In general from the current experiment, T2 tends to be more economical without affecting body weight, milk yield and milk composition.

Conclusion

Depending on availability and price of those supplements, using cottonseed cake as a protein supplement for oat-vetch hay basal diet is preferable in milk yield and composition compared to other treatments. However, protein supplementation should consider prices of added protein supplement versus increases in milk yield and also availability of those protein sources.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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