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Evaluating Substitution of Alfalfa Hay for Concentrate Feeds on Nutrient Intake and Growth Performance of Crossbred Dairy Heifers

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Abstract:
An experiment was conducted to evaluate different substitution levels of alfalfa hay for protein concentrates on growth performance, and feed intake of crossbred heifers. Twenty-four crossbred dairy heifers at the age of six months, with an average body weight of 111.1 ± 1.5 kg (mean ± SE) were selected and randomly assigned to four different feeds in a Randomized Complete Block Design for a period of 90 days, six calves per treatment. Maize Stover fed to all experimental animals adlibtum, at 20% refusal, as a basal diet supplemented with 69% wheat bran (WB), 30% noug seed cake (NSC) and 1% salt (T1) or substituting 50% NSC with alfalfa hay (ALH) (T2), or 75% NSC with ALH (T3), or 100% NSC with ALH (T4). Diets were formulated for similar crude protein and calories. Feed intake and body weight were measured and recorded daily and every 15 days, respectively. Results of the experiment indicated that the dry matter intake of maize Stover was significantly improved by complete substitution of alfalfa hay by noug seed cake. There was no significant difference in total dry matter intake ($P > 0.05$) in heifers supplemented with concentrate feeds and different levels of alfalfa hay. There is also no significant difference in daily body weight gain; final body weight and feed conversion efficiency (FCE) in heifers fed different levels of concentrate and alfalfa hay. In conclusion substitution of concentrate feed with different levels alfalfa hay resulted in similar body weight gain, and dry matter intake of crossbred calves. Similarly based on partial budget analysis, complete substitution of NSC with alfalfa hay showed reduction of feed cost and increase of net return.

Keywords: concentrates, alfalfa hay, substitution levels, intake, growth, crossbred cattle

INTRODUCTION

Replacement heifers represent the future potential of the dairy industry; as such, the feeding strategy for dairy heifers is to rear these animals at a minimum economic cost without reducing their future lactation performance (Hoffman *et al.*, 2007). In Ethiopia, dairy cattle are characterized by long age at first calving, long calving interval and low milk yield principally due to inefficient feeding and management practices, low genetic potential of the indigenous cattle, high level of disease, and parasitic incidence (Aynalem *et al.* 2011; Yigezu, 2003).Good quality feed improves livestock productivity, resulting in lower age at first calving and shorter inter-calving interval, thus increasing productive life and profitability (Linde *et al.*, 2002). Proper feeding also improves body resistance to diseases (Vighi *et al.*, 2008), welfare, and reproductive performance; enabling higher productivity under a given management regimen (Absalón-Medina *et al.*, 2012).

In Ethiopia, natural pasture (grazing) and crop residues are the major feed type contributing 54.5% and 31%, of the total diet respectively (CSA, 2021). However, these feed types are characterized by relatively low nutrient content, high fiber content, low digestibility, and low

voluntary intake (limited consumption) by animals. In Ethiopia, despite thousands of improved forage species and accessions have been tested and a number of them recommended for wider adoption in different agro-ecologies and production systems, they covered only 0.57% of the national feed source. Alfalfa (*Medicago saliva*), is among the leguminous forages important as sources of nitrogen, fermentable organic matter and minerals to supplement crop residues and poor-quality natural pasture-based diets. However, the optimal amount of alfalfa hay required in the diet of crossbred heifers is not well defined. Thus, the objective of this study was to evaluate the effect of substituting concentrate feeds with different proportion of alfalfa hay on feed intake and body weight gain of crossbred dairy cattle heifers.

MATERIALS AND METHODS

Study Area

The study was conducted at Adami Tulu Agricultural Research Center located 167 km south of Addis Ababa at latitudes of 7^{o} 9′ N and $38^{o}7'$E longitude in the semi-arid middle rift valley of Ethiopia. The area is situated at 1500 meters above sea level and the soil type of the area is fine, sandy loam with sand, and clay in the proportion of 34:48:18 respectively. The average annual rainfall is 760 mm. The minimum and maximum temperatures are 12.6 and 27^{o}c, respectively (ATARC, 2003).

Experimental Animals and Treatments

The experiment was carried out according to the guidelines of the Ethiopian Animal Experiments Inspectorate, Ministry of Livestock and Fisheries with respect to animal experimentation and care of animals under study. Twenty-four crossbred (Holstein Frisian and Arsi) heifers with six months of age and initial body weight of 111.1 ± 1.5 kg (mean ± SE) were used in the experiment. The animals were selected from heifers produced at the Adami Tulu Agricultural Research Center herd. The animals were quarantined for fifteen days to get them acclimatized to their new feed and to observe their health condition. At the end of the quarantine period, they were blocked into four blocks of six animals based on initial live weight and randomly assigned to one of the four treatment rations prepared. Randomized Complete Block Design (RCBD) was used with 4 treatments and 6 replications. The experiment was conducted for 105 days including 15 days of adaptation.

Animal Management, Feeds, And Feeding

Before the beginning of the experiment, the experimental animals were treated against internal and external parasites using broad-spectrum anthelmintic and ivermectin, respectively. The experimental animals were kept in individual pens and allowed to drink water two times a day. Alfalfa forage was planted on half of a hectare of land where irrigation water was used as supplementary water in the dry season. Alfalfa hay was harvested at the 10% blooming stage and allowed to wilt under the shed for 48 hours before use. After 48 hours the alfalfa hay was stored in a dry and aired place for later use. Maize Stover was fed to all experimental animals as a basal diet and a concentrate diet (CD) was prepared from 69% wheat bran (WB), 30% noug seed cake (NSC), and 1% common salt. The CD was offered at 3 kg DM/animal/day (NRC, 2001). Before the experiment started, samples of concentrate and basal diets were analyzed for the chemical composition of DM content. Based on the chemical composition the supplement ratios were formulated. Maize Stover fed to all experimental animals *adlibtum*, at 20% refusal, as a basal diet and supplemented with 69% WB and 30% NSC (T_1) or substituting 50% NSC with alfalfa hay (ALH) (T_2), or 75% NSC with ALH (T_3), or 100% NSC with ALH (T_4). The treatments were iso-caloric (6 Mcal/day) and iso-nitrogenous (12.4%) and were formulated to satisfy the energy and CP

requirements of a dairy heifer weighing 111.1 kg (NRC, 2001) (Table 14). The proportion of feed ingredients, the chemical composition of the supplement, the experimental diet, and feed ingredients are presented in Table 1.

Chemical Analysis

The DM, organic matter (OM), crude protein (CP), and ash were determined according to AOAC (2005). CP content was measured by the Kjeldahl method as N*6.25. The content of neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985).

Table 1: Nutrient composition (DM %) of experimental diets offered and refused

	Chemical composition						
Feeds offered	DM	OM	Ash	CP	NDF	ADF	ADL
Wheat bran	91.6	94	6.0	17.5	62.0	18.0	3.8
Noug seed cake	92.5	90.0	10.0	32.0	39.0	32.0	8.0
Alfalfa hay	91.5	91.5	8.5	20.0	40.0	30.0	6.5
Maize Stover	92.5	92.0	8.0	3.6	76.2	47.0	6.6
69 % WB:30% NSC	93.5	93.0	7.0	21.0	55.1	22.5	6.0
69 %WB:15%NSC:15%ALH	93.0	92.0	8.0	20.5	55.2	21.5	7.5
69 %WB:7.5%NSC:22.5%ALH	93.5	92.5	7.5	19.8	56.5	20.6	7.0
69 %WB:30%ALH	90.5	93.5	6.5	19.5	57.0	19.5	6.8
Refusal							
69% WB:30% NSC	94.0	93.0	7.0	14.0	50.5	20.8	4.5
70%WB:15%NSC:15%ALH	93.5	92.0	8.0	11.0	52.5	19.0	5.5
70%WB:7.5%NSC: 22.5%ALH	91.5	93.0	7.0	10.5	50.6	18.9	4.8
70%WB:30%ALH	92.5	94.0	6.0	9.5	51.2	15.2	5.0

DM: dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; WB: wheat bran; NSC: noug seed cake; ALH: alfalfa hay

Feed Intake and Conversion Efficiency

Animals were fed the experimental diets for 90 days in individual pens, and daily feed intake was recorded. The daily feed intake of individual animals was calculated as follows:

$$\text{Daily Feed intake (g)} = \text{amount of feed offered (g)} - \text{amount of feed refused (g)}$$

Feed conversion efficiency was calculated using the formula suggested by Gülten *et al*. (2000):

$$\text{Feed conversion efficiency} = \frac{\text{Average daily live weight gain (g)}}{\text{Average daily feed intake (g)}}$$

Live Weight Change and Daily Gain

The live weight of each animal was taken at every 15 days interval in the morning before provision of feed and water. The live weight change was calculated as the difference between the final body weight and initial live weights. Average daily gain (ADG) was calculated as:

$$Avergage\ daily\ gain\ (\text{g/day}) = \frac{Final\ body\ weight(\text{g}) - Initial\ live\ weight\ (\text{g})}{number\ of\ feeding\ days}$$

Partial Budget Analysis

The partial budget analysis was taken to determine cost-benefit (profitability) analysis of supplementation of different proportions of alfalfa hay instead of concentrate in the feed of crossbred dairy heifers. The partial budget analysis was calculated from the variable costs and benefits. At the end of the experiment, the selling price of each experimental calve was estimated by three experienced local calf dealers, and the average of those three-estimation prices was taken. The variable costs were calculated from supplementary feed and basal feed costs which are supplied for each experimental heifer treatment costs. The cost of alfalfa hay was estimated from the cost of land and daily labor used to produce and harvest the forage. The total returns (TR) were determined by calculating the difference between the estimated selling prices and the purchasing price of experimental heifers. Net return (NR) was calculated as;

$$NR = TR - TVC$$

The change in net return (ΔNR) was calculated as the difference between a change in total return (ΔTR) and the change in total variable costs (ΔTVC).

$$\Delta NR = \Delta TR - \Delta TVC$$

Statistical Analysis

The data collected on feed intake and body weight gain was subjected to an analysis of variance (ANOVA) model for RCBD using Statistical Analysis System Software (SAS version 9.1). When the differences in treatment means were significant at the probability level of $P<0.05$, the means were compared by using the Least significant difference (LSD) test. The statistical model used was:

$$Yij = \mu + Ti + Bj + Eij$$

Where,

- Yij = the dependent variable (feed intake and body weight gain),
- μ =overall mean,
- Ti = effect of i^{th} treatment (i=1- 4), and
- Bj=effect of j^{th} block (j=1…4)
- eij =random error.

RESULT AND DISCUSSION

The Chemical Composition of Treatment Feeds

The chemical composition of the feeds used in the present study is indicated in Table 1. The four experimental diets contained similar concentrations of CP and NDF.

Feed and Nutrient Intake

The DM and nutrient intake of heifers fed on experimental diets are presented in Table 2. The basal diet dry matter intake was significantly higher ($P<0.05$) in heifers fed on diets totally substituted by alfalfa hay. However, the TDMI intake was similar across all treatment groups. Heifers fed on diets with a high percentage of alfalfa hay consumed high maize Stover throughout the study, which supports the hypothesis that increasing high-quality forges in the diets increase the voluntary intake and digestibility of low-quality roughages. This is in agreement with Huawei

et al. (2017) who reported that including good-quality forages in the diet increases the dry matter intake of low-quality roughages in dairy heifers.

Table2: Feed intake of heifers fed on maize Stover and supplemented with different proportions of alfalfa hay and concentrates

Parameters	T1	T2	T3	T4	SEM	SL
Basal feed DM intake, kg/d	1.40^{b}	1.56^{ab}	1.60^{ab}	1.63^{a}	0.08	*
Supplement DM intake, kg/d	2.48	2.46	2.50	2.73	0.05	NS
Total DM intake, kg/d	3.90^{b}	4.0^{ab}	4.1^{ab}	4.4^{a}	0.12	*
DM intake, % BW	2.48b	2.52^{ab}	2.55^{ab}	2.77^{a}	0.13	NS

$^{a, b,}$ means with different superscripts in a row are significantly different. * = (P < 0.05); DM: dry matter; BW: body weight; NS: non-significant; SEM: standard error of mean; SL: significant level.

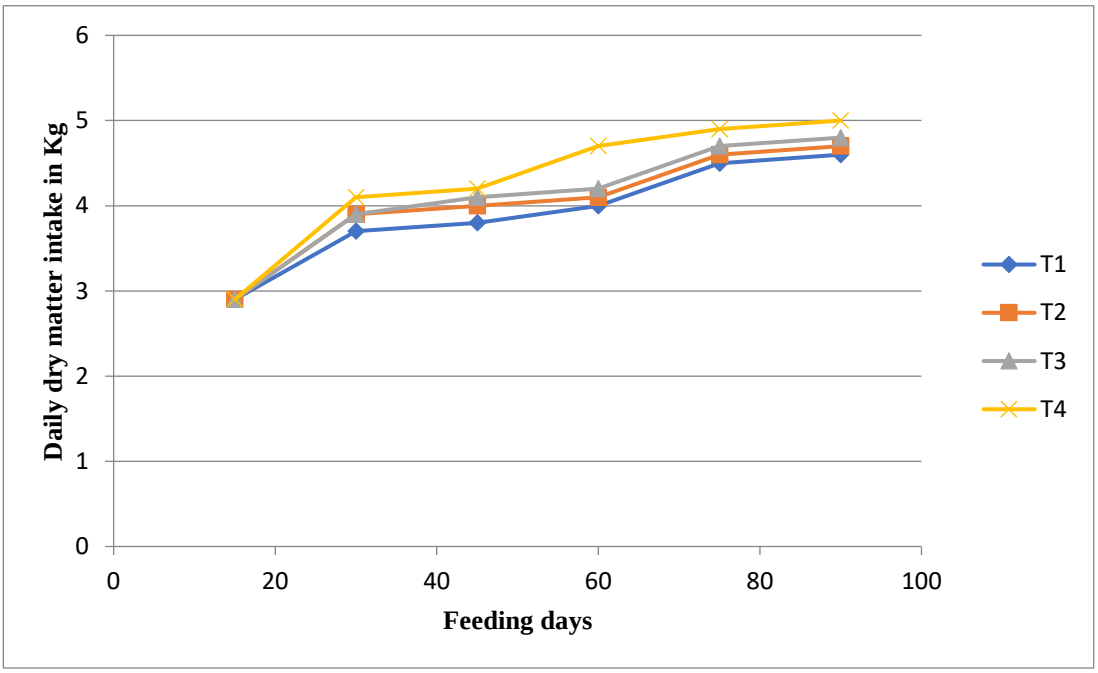

Figure 1: Trends of daily dry matter intake of crossbred dairy heifers fed different maize Stover, concentrates, and alfalfa hay

Body Weight Gain

Mean values of initial and final body weight (BW), daily BW gain, and feed conversion efficiency (FCE) of the experimental animals is indicated in Table 3. The result indicated that there is no significant difference in average daily weight gain and final BW, FCE of experimental animals (P > 0.05).

Table 3: Effects of supplementing concentrate feeds and alfalfa hay on body weight gain of crossbred heifers

Parameters	T1	T2	T3	T4	SEM	SL
Initial body weight, kg	109.3	111.4	111.5	112.0	1.5	NS
Final body weight, kg	157.2	159.5	160.6	159.6	2.01	NS
Body weight change, kg	47.8	48.1	49.0	47.6	2.18	NS
Daily body weight gain, kg/day	0.53	0.54	0.55	0.53	0.02	NS
FCE, kg DBWG/ kg DDMI	0.13	0.13	0.13	0.12	0.01	NS

SEM = standard error of mean; SL = significant level; ns= non-significant; FCE: feed conversion efficiency; DBWG: Daily body weight gain; DDMI: daily dry matter intake

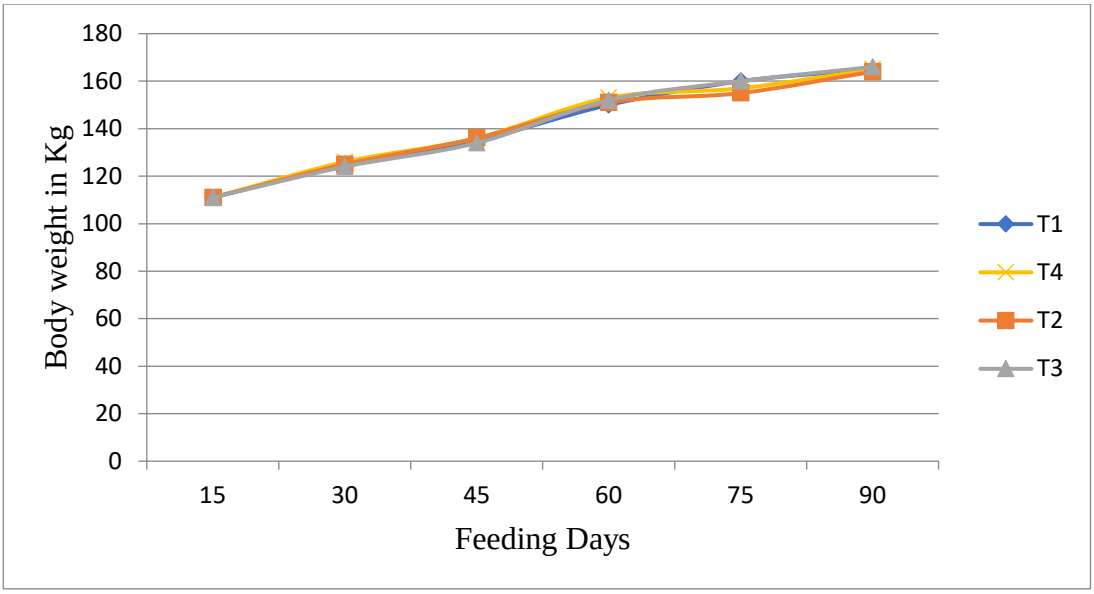

Figure 2: Trends in body weight gain of crossbred dairy heifers fed maize stover and supplemented with different proportions of concentrate and alfalfa hay.

Partial Budget Analysis

The partial budget analysis of crossbred heifers fed on maize stover, concentrate, and different proportions of alfalfa hay are presented in Table 4. The partial budget analysis was performed to evaluate the economic advantages of the use of alfalfa hay at different proportions instead of NSC of concentrates. The result of this study indicated that higher net return (3748.3 ETB/heifer) was obtained from the calves supplemented with wheat bran and alfalfa hay substituting 100% NSC (T4) followed by heifers supplemented with 50 (T2) and 75% (T3) alfalfa hay. The result of the current study revealed that total variable cost was decreased as the level of alfalfa hay increased across the treatment.

Table 4: Partial budget analysis of crossbred heifers fed on maize stover and supplemented with different proportions of concentrates and alfalfa hay

Parameters	Treatments			
	T1	T2	T3	T4
Estimate purchase price of calf (ETB/heifer)	10,000	10,000	10,000	10,000
Maize stover consumed (kg/heifer)	126.0	140.4	144.0	146.7
Alfalfa hay consumed (kg/heifer)	0	40.5	60.75	81
Wheat bran consumed (kg/heifer)	189.0	189.0	189.0	189.0
Noug seed cake consumed (kg/heifer)	81.0	40.5	20.25	0
Total feed consumed (kg/heifer)	3.9	4.0	4.1	4.4
Cost of maize stover (ETB/heifer)	504.0	561.6	576.0	586.8
Cost of alfalfa hay (ETB/heifer)	0	425.25	637.87	850.5
Cost of Wheat bran (ETB/heifer)	1814.4	1814.4	1814.4	1814.4
Cost of Noug seed cake (ETB/heifer)	1336.5	668.25	334.12	0
Total variable cost (ETB/heifer) (TVC)	3654.9	3469.5	3362.39	3251.7
Gross income (R) (ETB/heifer) (estimate sale price)	17,000	17,000	17,000	17,000
Total return (TR) (ETB/heifer)	7,000	7,000	7,000	7,000
Net return (NR) (ETB/heifer)	3345.1	3530.5	3637.61	3748.3

NB: 1kg wheat bran= 9.6 ETB; 1kg of NSC= 16.50 ETB; 1kg maize Stover =4 ETB

CONCLUSION

From the current result, it is possible to conclude that the complete substitution of alfalfa hay for noug seed cake improved the dry matter intake of maize stover without affecting the growth performance of crossbred dairy heifers. This implies alfalfa hay can substitute the feeding value of protein-rich conventional feeds (noug seed cake). Similarly based on partial budget analysis, the complete substitution of alfalfa hay instead of noug seed cake showed a reduction in feed cost and an increase in net return. It can also be possible to conclude that alfalfa hay can replace the highly valued commercial protein source feeds because of their similar performance (feed intake and daily weight gain) effects on breeding heifers. Generally, all supplements used in this study induced favorable average daily gain and positive net return and thus can be employed in feeding systems of replacement heifers depending on their availability and comparative cost.

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