COWPEA HAY AS A PARTIAL SUBSTITUTE FOR CONCENTRATE: EFFECTS ON MILK YIELD AND COMPOSITION

HUSSIEN, B.[1,2*] – BEKELE, B.[1] – KUMBE, A.[1] – ONETA, A.[1]

[1] *Oromia Agricultural Research Institute, Yabello Pastoral and Dryland Agriculture Research Center, Yabello, Ethiopia.*

[2] *Oromia Agricultural Research Institute, Adami Tulu Research center, Batu Ethiopia, Ethiopia.*

**Corresponding author*
e-mail: beshirhussein02[at]gmail.com

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Abstract. The study was carried out in Yabello Pastoral and Dry Land Agricultural Research Center to investigate the effect of replacement of cowpea (Vigna Unguiculata) for concentrate mix on milk yield and composition in lactating Borana cows fed Rhodes grass hay as a basal diet. Four lactating Borana cows of similar milk yield, body weight and stage of lactation were arranged in 4 x 4 Latin square design. The treatments included offering Rhodes grass hay a basal diet ad libitum with different proportions of concentrate mix and cowpea hay. T1= 100% concentrate mix and 0% cowpea hay (control), T2= 65 % concentrate mix and 20% cowpea hay, T3= 65% concentrate mix and 35% cowpea hay and T4= 50% concentrate mix and 50% cowpea hay. There were no significant differences (P>0.05) in dry matter and nutrient intakes among treatment groups, while milk yield was significantly different (P<0.05) among treatments. The overall mean of daily milk yield was 4.05 kg/day. Cows that were receiving 100% concentrate mix (T1) produced the highest milk yield (4.18 kg/day) followed by cows receiving the diet in which 50% of the concentrate mix was replaced by cowpea hay (T4).Except milk yield, cowpea hay can substitute up to 50% of the concentrate mix without adversely affecting feed intake, nutrient intake and milk composition of lactating Borana cows fed Rhodes grass hay as basal diet. Therefore, to improve their milk production, smallholder farmers can use cowpea hay 50% to replace the concentrate mix in feeding their cows on poor pasture, especially during dry seasons.
Keywords: *cowpea, hay, milk yield, lactating cows, Rhodes grass*

Introduction

Ethiopia has the largest livestock population in Africa estimated at 56.71 million head of cattle, 29.33 million sheep, 29.11 million goats, 7.43 million donkeys, 2.03 million horses, 0.4 million mulls, 1.16 million camels, 56.87 million poultry and 5.89 million beehives. Despite a large livestock population, the productivity of animals is very low. However, with rapid population and income growth, and increasing urbanization, the demand for livestock and livestock products is growing, and these present huge opportunities for the sector mainly the dairy sector (Yilma et al., 2006). In Ethiopia, domestic dairy production largely depends on the traditional way of production under different systems. The production systems belong to either the rural smallholder (mixed crop-livestock) production, pastoral and agro-pastoral production, urban and peri-urban smallholder dairy production, or specialized commercial dairy production system. Pastoral and agro-pastoral production system comprises the vast lowland areas of the country where arid and semiarid agro–climates dominate and subsistence is mainly based on livestock and livestock products, milk being the main source of food, except in agro-pastoral areas where some crops are produced. In all

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dairy production systems of the country, the productivity of indigenous dairy cows is very poor. In addition to animal health problems, lack of adequate quantity and quality of feed is a major cause of poor livestock productivity. The use of improved feeds is limited (0.3%) in rural areas of Ethiopia. Native pasture grass is the major feed resource (56.23%) followed by crop residue (30.06%). Hay and by-products are also used as animal feed comprising about 7.44% and 1.21% of the total feeds, respectively. The main source of feed for the animal is standing hay, which is poor in quality and limited in supply. This leads to dry season feed shortage in quantity and quality. The digestibility and intake of these feeds are low thus resulting in poor performance of the animals (Wamatu et al., 2019). Despite their potential economic benefits, cereal grain and concentrate as supplements to low-quality feeds are unaffordable by smallholder farmers, in addition to their scarcity because of grain use as human food. Therefore, there is a need to look for other protein sources that farmers/pastoralist could grow on their own farm with minimum cost.

Borana pastoral area is a part of the lowlands of Ethiopia where livestock husbandry is the essential part of the production system, and livestock serve as a source of cash income and food supply for households. Feed shortage is one of the critical factors that affect milk production and productivity of dairy cattle in Borana pastoral areas. Cowpea is one of the forage legumes used for livestock feeding and is the most popular legume used for its grain in Africa, particularly in Sub-Saharan. Most of the farmers grow local cultivars for seed production and biomass and used the haulms for feeding selected animals such as sick, lactating and castrated animals Cowpea is an excellent source of protein containing 19.5 -26%. This justifies that it could be a good substitute for the more expensive concentrates (Owolabi et al., 2012). A study Abera and Marsha (2016) showed that cowpea hay can replace up to 50% of concentrate mix without any significant reduction in milk yield under semi-arid conditions and valuable economic alternatives to purchased protein or energy-rich concentrates as a practical solution for smallholder dairy production. As a result, this study was designed to evaluate milk yield and composition of Borana cows supplemented with cowpea hay as a protein source. The objective of this study was to evaluate the effect of substitution of concentrate mixture with cowpea hay on milk yield and composition in lactating Borana cows fed rhodes grass hay as basal diet during dry season.

Materials and Methods

Description of the study site

The experiment was conducted in Borana zone at Yabello Pastoral and Dryland Agriculture Research Center (YPARC) which is located about 567 km to the south of Addis Ababa on the main road to Moyale. The Borana plateau is divided into four major seasons. Rainfall is bimodal, 60% of the rainfall occurs between March and May (main rainy season) followed by a minor peak between September and November (short rainy season). The average annual rainfall ranges from 350 and 900 mm. Livestock production is the main stay of the pastoral and agro-pastoral community of the Borana people. The major livestock raised are cattle, camel, goat, and sheep. Crop production is also practiced in the area.

Experimental animals and management

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A total of four Borana breed cows were used for the experiment. Experimental cows with the same early stage of lactation, similar body weight, but different parity were used for experiment from the total dairy herd available in YPDARC. All cows were drenched with broad-spectrum antihelminthics (Albendazole 500 mg) and sprayed with diazinol for external parasites prior to commencement of the experiment. Careful observation and follow up has been undertaken for the occurrence of any health problem and disorders during the experimental period. The experimental animals were individually managed in a well-ventilated barn with concrete floor and appropriate drainage slope and gutters. Throughout the experimental period, animals had free access to water while basal and treatment diets were offered in the milking parlour individually. The cows were hand-milked twice daily at approximately 12-hour intervals in the milking room.

Feed preparation and feeding management

Rhodes (Chloris gayana) grass hay was established at Yabello Agricultural Research Center on-station on four hectares of land. Fertilizer (DAP) at the rate of 100 kg/ha was applied during the year of establishment in 2020. Partially dried Rhodes (Chloris gayana) grass hay was offered ad-libtum (adjusted up to 20% refusal) in the morning hours after it was chopped to 10 cm-20 cm in order to minimize selection. On other hand, Cowpea hay was harvested when 25% of the pods were colored. Then it was chopped and stored under a hay shade and used throughout the experimental period. The amounts of cowpea hay was given depending on the percentage of crude protein it is supposed to replace in the concentrate feed. In other words, the amount of cowpea hay to be given was adjusted depending on the CP in the formulated concentrate mixture in such a way that an equivalent CP was supplied by the cowpea hay. The concentrate was purchased from Adama town and the quantity of the concentrate mix offered daily was at the rate of 0.5 kg/l of milk produced by each cow with equal portions during the morning and evening milking time. Feed refusals were collected and weighed before the next feeding. Feed intake was calculated as the difference between the quantity of feed offered and feed refused.

Experimental design and treatments

At the beginning of the experiment, five cows were randomly assigned in 4X4 Latin square design to the control and intervention diets that consisted three levels of cowpea hay replacement for concentrate mix. Supplementation diets were offered during milking time. There were four periods each consisting 21 days. During the first 7 days of each period, animals were acclimated to the experimental diet and the remaining 14 days were used as experimental period when data collection was undertaken. Hence, the experiments took 84 days; being started in March 2021 and finished in May 2021. The four dietary treatments were: (1) T1=Concentrate mix (100%) (0.5 kg/1kg of milk)+RGH ad libitum (control); (2) T2=Concentrate mix (80%)+Cowpea hay (20%)+RGH ad libitum; (3) T3=Concentrate mix (65%)+Cow pea hay (35%)+RGH ad libitum; (4) T4=Concentrate mix (50%)+Cowpea hay (50%)+RGH ad libitum. The concentrate mixture was composed of 49.5% wheat bran + 49.5% noug seed cake +1% salt. The basal feed was offered ad libitum at a 20% refusal rate and the offer was adjusted every four days. Adjustments for concentrate offer was made at the end of each period and for each treatment based on the actual milk produced. The amounts of cowpea given were calculated depending on the amount of CP in the concentrate to be replaced thus making the diets iso-nitrogenous.

Experimental measurement

Chemical analysis of the feed samples was undertaken at Hawassa university, Animal Nutrition Laboratory. The samples were dried in an oven at 105°C overnight in a forced draft oven to determine the DM contents of the feed. Other feed samples were partially dried at 65oC and ground to pass through 1mm size screen for chemical analysis. Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined following the procedures of Van Soest and Robertson, 1985). The ash and Nitrogen (N) content were analyzed according to the procedure outlined by AOAC and Horwitz (1960). Milk yield from each cow was measured using a graduated measuring cylinder. Lactating cows of each group were manually milked twice a day at 8:00AM and 6:00PM. Milk consumed by the calves was calculated as the difference in the weight calves before and after suckling. For analyzing milk chemical compositions, representative milk samples of 100 ml were taken from each cow in the morning and afternoon twice every week during the experimental period. Then keeping in refrigerator for a while, milk fat, protein, total solid, ash and lactose percentage were determined by using a Lacto Scan milk analyzer (Milk otronic Ltd, Nova Zagora, Bulgaria). In addition, the following simple arithmetic was used to calculate some chemical entities of milk. SNF=(TS−fat) x 100; Percent ash=[(Weight of residue)/ (Weight of sample)] x100; Percent lactose=Percent total solids – (% fat+ % protein+ % total ash).

Partial budget analysis

The partial budget analysis and marginal rate of return were calculated to determine the profitability of the different supplemental feeds. Net income (NI) was calculated as the amount of money left when total variable cost (TVC) was subtracted from total returns (TR). In this experiment the variable costs included estimated purchase price of the supplemental feed, and labor cost for preparation of the supplemental feeds. While total return (TR) was estimated as the average sale price of milk produced per animal per day during the experimental period . Net income (NI) = TR-TVC.

Statistical analysis

Data of milk yield and compositions were subjected to GLM procedure for Latin Square Design using StatisticalbAnalysis System. Treatment means were separated using Least Significant Difference (LSD) at α=0.05. The model used for analysis of the data was: Yijk=μ+Ci+Pj+Tk+Eijk; where μ=Overall mean; Ci=Cow effect (parity); Pj=Period effect; Tk=Treatment effect; Eijk=Experimental error.

Results and Discussion

Chemical composition of the experimental feeds

Chemical composition of the experimental feed is presented in *Table 1*. The DM content was almost similar for feeds used in the experiment. The dry matter (DM) content of formulated concentrate mix in the current study agrees with the mean DM content of 91.09% reported by Gobena and Hundie (2020). On the other hand, the DM content of cowpea hay was found to be similar with the finding of Abera and Marsha (2016) in which the DM content of 90.64% was observed. The highest CP content was noted in Nougseed cake, followed by concentrate mixture and Cowpea hay in that order. The CP content of cowpea hay in the current experiment is within the range of 18.78 to 20.22% observed by previous study for cowpea forage fertilized with different levels of fertilizer. However, in comparison to the CP contents of 21.03% reported by Abera and Marsha (2016), the cowpea hay in the current study exhibited lower CP contents. This might have resulted from the stage of harvest and loss of nutrients during the hay making process in the present trial. The supplements of concentrate mix and Cowpea hay have lower NDF and concentrations relative to the Rhodes grass hay used. The low levels of NDF in both supplements are indicative of high cell soluble matter. The same trend was observed for ADF contents with the highest value recorded for rhodes grass hay followed by cowpea hay and the noug seed cake. The neutral detergent fiber NDF content of Rhodes grass hay was higher than the value of 70.22% reported by Kumsa et al. (2016) and lower than the value of 80.8 % reported by Gobena and Hundie (2020). This difference in neutral detergent fiber NDF content might be attributed to the difference in stage of maturity at the harvest, type of soil, seasonal variation and the difference in management during conservation of Rhodes grass for hay.

***Table 1**. Chemical composition of the experimental feed.*

Feed type	DM	Ash	CP	NDF	ADF	ADL	Hemi.	Cell.
RGH	91.46	11.22	8.14	72.59	47.36	5.92	24.45	41.44
Cowpea hay	90.34	12.10	19.03	48.18	31.42	5.78	16.76	25.64
Wheat bran	90.75	6.87	17.21	44.04	12.76	4.1	31.28	8.66
NSC	92.97	9.55	31.03	40.20	29.65	7.95	10.55	21.7
Conc.mix	91.67	6.83	20.79	28.99	13.01	5.38	15.98	7.63

Note: ADF=Acid detergent fiber; ADL=Acid detergent lignin; Cell.=Cellulose ; Conc. mix=Concentrate mix; CP=Crude protein; DM=Dry matter; Hemi.=Hemicellulose; NDF=Neutral detergent fiber; NSC=Noug seed cake; OM=Organic matter; RGH=Rhodes Grass Hay.

Dry matter and nutrients intake

The overall mean feed dry matter and nutrient intakes of cows in the feeding treatments are presented in *Table 2*. There was no significant difference (P>0.05) in dry matter intake among the treatment groups. The present study is disagreement with the findings of (5) in which the replacement of concentrate with cowpea hay at the rate of 50% increased the total DM intake of cows significantly (P<0.05) over those cows received cowpea hay at other lower rates of replacement. Crude protein and MEI intakes have followed the same trend as dry matter intake which is not significant (P>0.05) among treatment group. The highest MEI (63.29 MJ/head/day) obtained from 100% Concentrate mix (T1) is far from the estimated daily ME requirement (97.6 MJ/head/day) of lactating cows weighing 400 kg and producing 8-10 kg milk of 4.5% butter fat. But the mean ME intake obtained in this study is sufficient to meet the daily requirement for ME of cows with a mean daily milk yield of 4.05 kg/cow/day. Neutral detergent fiber and Acid detergent fiber intakes were also no significantly different (P>0.05) among treatment groups.

***Table 2**. Dry matter and nutrients intake.*

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Intake (Kg/day)	T1	T2	T3	T4	Mean	SL	SEM
Total DMI	7.59[a]	7.48	7.46	7.55	7.52	ns	±0.43
DMI (% LW)	2.76	2.72	2.71	2.75	2.74	ns	±0.11
Total CP	0.95	0.90	0.88	0.92	0.91	ns	±0.08
Total ME(MJ/day)	63.29	62.1	62.05	62.85	62.57	ns	±2.34
Total NDF	4.56	4.18	4.16	4.51	4.26	ns	±0.02
Total ADF	3.76	3.21	3.26	3.39	3.41	ns	±0.01

Note: [ab] means with the same superscripts within row are not significantly different (P>0.05); ADF=Acid detergent fiber; CP=Crude protein; DM=Dry matter; ME=Metabolisable energy; NDF=Neutral detergent fiber; NS=Not significant; SEM=Standard error mean.

Milk yield and milk composition

Mean milk yields of the cows in each treatment are presented in *Table 3*. Milk yield was significantly different (P<0.05) among treatments. Cows those received the 100% concentrate mix (control) (T1) produced the highest milk yield followed by those received the 50% level of cowpea hay replacement for concentrate mix (T4). The lowest milk yield was recorded for cows fed the 20% and 35% level cowpea hay replacement for concentrate mix. Abera and Marsha (2016) also found no significant difference (P>0.05) in daily milk yield between cows fed 100% concentrate mix and those fed cowpea hay up to 50% level of replacement for concentrate mix. The lactation curve in *Figure 1* represents the milk yield for a lactation period of 56 days. Cows on all dietary treatments reached peak milk yield between 5th and 6th weeks, but retained that peak lactation for short period (*Figure 1*).

***Table 3**. Effect of replacement of concentrate mix with different proportions of Cowpea hay on milk yield in lactating Borana cows fed rhodess grass hay.*

Treatment	Milk yield
T1	4.18[a]
T2	3.96[b]
T3	3.95[b]
T4	4.10[a]
Mean	4.05
Significance level	**
SEM	0.05

Note: [a-c]means within column having different superscript are significantly different at; (*)=P<0.05; SEM=standard error of mean.

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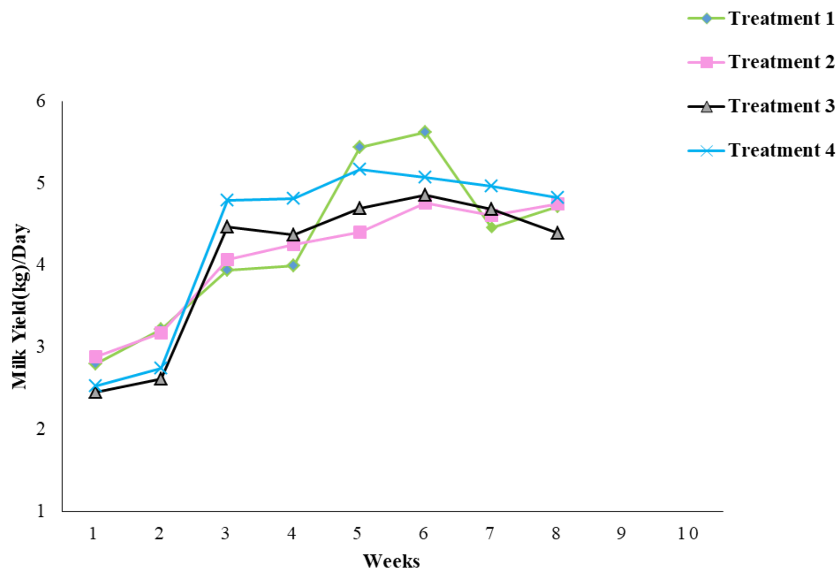

Figure 1. *Lactation curve of lactating cows fed on ad libitum rhodess grass hay supplemented with different proportions of cowpea hay as partial replacement to concentrate mix.*

The mean values for CP, fat, total solids, solid-no-fat, ash and lactose contents of milk from cows in different treatments are presented in *Table 4*. Except for milk fat, treatment effects were non-significant (P>0.05) for milk protein, ash, lactose, solids not fat and total solid components. The highest and lowest values for fat content (4.37 and 3.77%) were observed for T3 and T1 respectively (Sairanen et al., 2006). Observed higher milk fat content for cows allocated only green hay. This is due to fact that, rations with more concentrates may result in changes in proportion of ruminal VFA, which in turn can result in the reduction of milk fat like in T1 of the current study. But difference between T2, T3 and T4 in fat percent might be due to the difference in the forage characteristics such as forage particle size, maturity, and fiber content of the forage. However, the higher level of CP intake by the animals did not significantly affect the concentration of milk protein in the current trial. This agrees with the conclusion made by Kitaw et al. (2010). the mean value of lactose observed in the present study is (4.64%) is slightly higher the findings by this author. The total solid perecentage (12.80%) observed in the present study contrasts with the value of 15.05% reported earlier (Abera and Marsha, 2016)). This difference could be associated with the difference in breeds of cows used in the two experiments.

Table 4*. Effect of replacement of concentrate mix with different proportions of cowpea hay on milk composition in lactating Borana cows fed rhodess grass hay.*

Treatment	Fat	protein	Ash	Lactose	SNF	Total Solid
T1	3.77[b]	3.18	0.77	4.81	8.76	12.75
T2	3.99[b]	3.13	0.74	4.72	8.59	12.36
T3	4.37[a]	3.37	0.64	4.88	8.89	13.26
T4	4.17[a]	3.17	0.74	4.77	8.68	12.85
Mean	4.08	3.21	0.72	4.64	8.73	12.80
SEM	0.3	0.06	0.3	0.06	0.12	0.42
SL	*	ns	ns	ns	ns	ns

Note: [a-b]means within column having different superscript are significantly different at (*)=P<0.05; SEM=standard error of mean.

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Partial budget analysis

The partial budget analysis for feeding lactating Borana cows with basal diet of rhodes grass hay supplemented with different proportions of cowpea hay as replacement for concentrate mix is summarized in *Table 5*. In the present study, though the difference among treatments was not significant, highest net return (15,744.4 ETB) was obtained from cows fed with 50% cowpea hay replaced concentrate mix (T4) than cows in other treatment groups. This might be due to the fact that the higher milk yield obtained from cows in this treatment combined with the lower cost incurred during cowpea hay production than buying concentrate mix.

Table 5*. Partial budget analysis of lactating Borana cows fed basal diet of rhodes grass hay supplemented with different proportions of cowpea hay as replacement for concentrate mix.*

Variables (birr)	T1	T2	T3	T4
Days of Experiment (days)	70	70	70	70
Feed Cost/Cow/Day	38.66	30.09	25.18	21.08
Milk Yield/Cow/Day(liter)	4.18	3.96	3.95	4.1
Feed Cost Per kg of milk/day	9.25	7.6	6.37	5.14
Gross Income (GI) /day	250.8	237.6	237	246
Total Cost/cow/Experimental Period	2706.2	2106.3	1762.6	1475.6
Total Revenue	17,556	16632	16590	17220
Net Return	14,849.80	14,525.70	14,827.40	15,744.40
Benefit Cost Ratio – BCR =TR/TC	6.49	7.9	9.41	11.67
Rate of Return – RR=NR/TC	5.49	6.9	8.41	10.67
Gross Ratio – GR= RR/BCR	0.85	0.87	0.89	0.91

Conclusion

Cows fed on all level cowpea hay replacement for concentrate mix produced almost the same amount of milk daily as those cows fed on control (T1). This trend was also true for feed intake and nutrient intake. Except Fat, all milk composition was not significance difference (P>0.05) among all treatment groups. The result of partial budget analysis also indicated that cows receiving 50% level cowpea hay replacement for concentrate mix (T4) provided higher profit and thus being economically beneficial than the cows those received the other two levels of cowpea hay replacement and the control group (T1). In general, except milk yields, inclusion of cowpea hay up to %50 as substitute for concentrate mix without adversely affecting feed intake, nutrient intake and composition. Highest economic benefits was gained on cows fed on T4 (50% cowpea level). Therefore, considering these potentials, smallholder dairy farmers can use 50% cowpea hay to replace the concentrate mix for cows on poor pasture, especially during dry season to improve their milk production.

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Conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper and they have contribution from collection to analyzing of data according to their sequences.

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