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ORIGINAL ARTICLE

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Effect of urea-molasses-treated highland bamboo leaves supplementation on lactating crossbred dairy cows nutrient utilization, body weight, milk yield and its composition and economic performance under on-farm condition in Guagusa Shikudad district, Ethiopia

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Abstract

Background: In Ethiopia, locally available feed resources are commendable in livestock production to make the sector sustainable and productive.

Objectives: This on-farm evaluation was conducted to evaluate the effect of urea-molasses-treated highland bamboo (*Yushania alpina*) leaves (UMTHBL) in lactating crossbred dairy cows' nutrient utilization, body performance, milk yield and quality and economic performance.

Methods: On-farm feeding trial was conducted using 12 lactating cows with initial body weight (328.08 ± 0.98 kg), initial milk yield (3.14 ± 0.78 L) of uniform parity (2) and stage of lactation (early) using a Randomized Complete Block Design. Three dietary treatments, namely, 6 h grazing (control) + concentrate (T1), control + UMTHBL ad lib (T2), control + untreated BL adlib (T3) with three replications were used. Analysis of variance was employed for the feeding trial data analysis.

Results: The UMTHBL increased more dry matter and nutrients intake than untreated. A significant difference ($p < 0.05$) was recorded between UMTHBL feeding (T2) and T1 and T3 in terms of increased milk yield. The highest (6.26 L) and the lowest (3.27 L) mean milk yield per day were recorded for cows fed UMTHBL and the control group, respectively. Urea-molasses treatment improved the crude protein (CP) and reduced fibres content than untreated. Treatment effects were not-significant ($p > 0.05$) for milk compositions. Similar to milk yield, dairy cows in T2 consumed more CP which is also reflected in higher body weight and economic benefit.

Conclusion: It can be concluded that employing treatment technology for highland bamboo leaves could support the crossbred dairy cows' production in smallholder farmers.

KEYWORDS
bamboo leaf, Guagusa Shikudad district, milk composition, milk production, urea-molasses treatment

1 | INTRODUCTION

The majority of dairy products in the country are coming from the smallholder production system. In response to the high demand of dairy products in the country, cross-breeding with high yielding animals is commendable practice; being duly considered in Ethiopia livestock master plan (Shapiro et al., 2015). Dairy production and productivity are, however, very low as compared to the neighbouring countries like Kenya. The average estimated daily milk yield of local and cross bred dairy cows under smallholder production system was found to be 1.2 and 8 L, respectively (Kebede, 2009; Worku, 2014). But, this milk yield for the crossbred dairy cows is below its genetic potential which is about 15 L/day. Among the constraints prevailing in the dairy sector of Ethiopia, the shortage of year round quality and quantity feed is taking the lion share. Especially in the dry season, there is a critical feed shortage in both quality and quantity.

The major feed resources in Ethiopia are natural pasture and crop residues (CSA, 2020). Nutritionally, however, it could not satisfy the maintenance requirement of the dairy cows. Agro-industrial by-products are expensive and are not accessible to the majority of the livestock keepers. Improved forage utilization and adoption are very limited; below 2% livestock feed contribution (CSA, 2020). Milk production is not maintained in the dry season as the feed resource could not satisfy the animal's physiology unless otherwise they are supplemented with energy and protein diets. It is common that animals in the dry season are losing their body weight (Yigardu et al., 2019). Hence, looking for other alternative locally available feedstuff especially in the dry season and evaluating its nutritional value for the inclusion in the dairy cattle diet is demanding. Bamboo grass is a promising candidate, in this case.

Bamboo is a perennial, fast growing and multiple advantageous grass in Ethiopia. The highland bamboo (*Yushania alpina*) and lowland bamboo (*Oxytenanthera abyssinica*) are the two indigenous grasses growing in highland and lowland, respectively, agro-ecologies of Ethiopia. Highland bamboo is growing in the form of different land uses, and the backyard production system is the predominant one (Mekuriaw et al., 2011). It is an evergreen grass when most of the forage plants in the natural pasture are dried during the dry season. It plays an ample role in the traditional life of farmers in Agew Awi zone of Amhara Region (Mekuriaw et al., 2011; Sirawdink, 2017) and day-to-day life of the households, and it is source of income for many farmers and urban inhabitants engaged in off-farm activities (BoA, 2012). Therefore, it could be integrated with the livestock production especially the stall feeding system. Bamboo leaf feeding to livestock in the form of fresh leaves is a common practice in the dry season in bamboo growing area in Ethiopia (Mekuriaw et al., 2011). Though it is a good protein and mineral source, its roughage characteristics demands feed processing techniques like ensiling. Ensiling the highland bamboo is not common in Ethiopia, but Adugna et al. (2020) reported that urea-molasses-treated lowland bamboo leaves improved the sheep performance than the untreated leaves. Similarly, Andriarimalala et al. (2019) in Madagascar reported that untreated bamboo leaves did not affect the dairy cows' milk yield by replacing maize silage in a mixed ration.

Evaluating the nutritional quality of ensiled bamboo leaves is an important step to incorporate it into the diet for dairy cattle in dry season. The use of bamboo leaves as fodder could increase farmers' economic and food security by ensuring milk production, reducing the feed costs the farmer enforced to buy it in the dry season. Bamboo leaf is an excellent animal fodder as it contains 18%–22% protein (Debeko, 2010). It has the highest amount of crude protein (CP) and good for milking animals during the 305 days lactation period for more milk yield. Due to its availability in the form of green during the dry season, bamboo leaves can be an alternative source of fodder for dairy cattle and maintain their milk production during the dry season without losing their body weight. In the present study, it was hypothesized that the ensiling of highland bamboo leaves with urea molasses could improve the biological and economic performance of crossbred dairy cows. Hence, the on-farm feeding trial was carried out with the objectives of evaluating the effect of urea-molasses-treated highland bamboo leaves (UMTHBL) in lactating crossbred dairy cows' nutrient utilization, body performance, milk yield and quality and economic performance.

2 | MATERIALS AND METHODS

2.1 | Description of the study area

The study was conducted in Guagusa Shikudad district, located in north eastern of Ethiopia at 420 km from Addis Ababa and 130 km from Bahir Dar (Figure 1). The district is bordered with Bure district in the East, Wonbera in the South, Sekela in the North, Ankesha in the West and Banja in the North West direction. The study area is bounded by the latitude of 11°92′–11°91′ N and longitude of 28°61′–28°87′ E. The altitude of the area ranges from 2451 to 2537 m above sea level (masl)

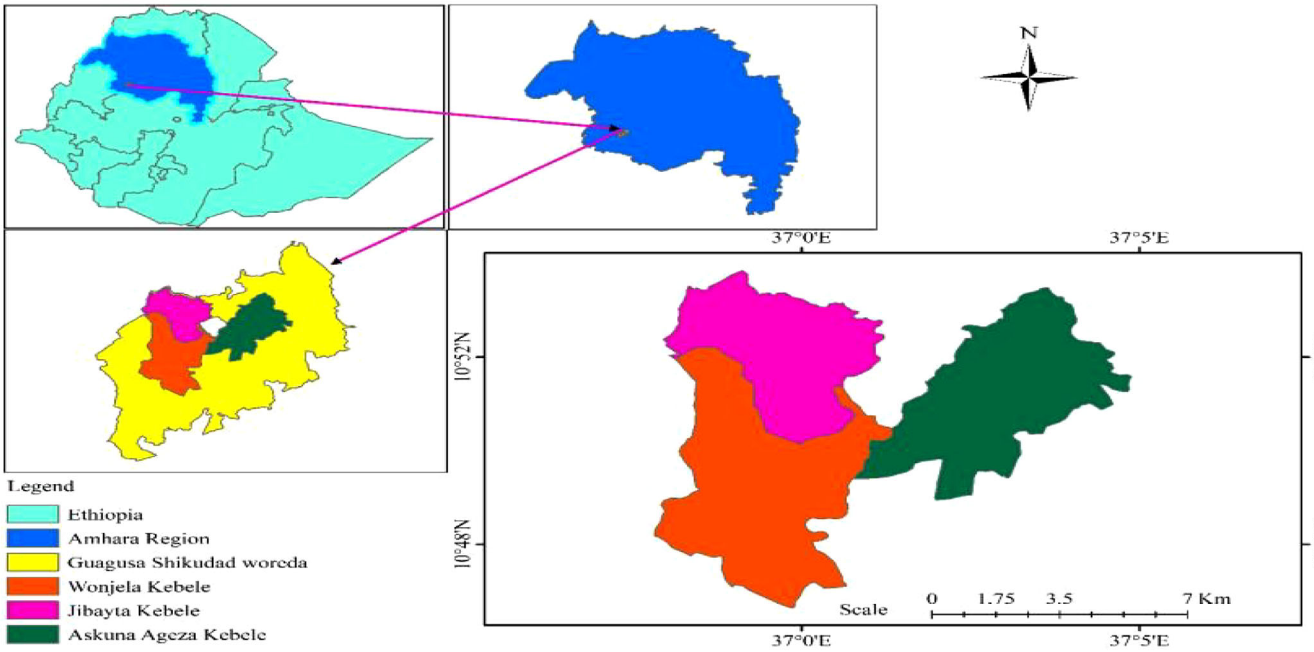

FIGURE 1 Geographical location map of Guagusa Shikudad district and selected kebeles/peasant associations (PAs) done by GIS.

with a slope of 2.6%–3.7% (Guagusa Shikudad District Agriculture Office, 2022). Guagusa Shikudad district has two climate conditions, namely Weina Dega (70%) and Dega (30%). The minimum and the maximum annual rain fall and diurnal temperature range from 1140 to 3572 mm and 10 to 25°C, respectively (Guagusa Shikudad District Agriculture Office, 2022; Belay, 2016). The average mean annual rainfall is 2491.9 mm with mono-modal system extending from March to the end of November, whereas the peak is in July and August (Shibabaw et al., 2018).

According to the Central Statistical Agency of Ethiopia (CSA, 2007), this district has a total population of 83,930, of whom 41,427 were men and 42,503 women; 9043 or 10.78% were urban inhabitants, and others were rural dwellers. The district has a total area of 296.04 km^2. The district has a total of 14 kebeles, from which 2 are urban and 12 are rural peasant associations (PAs). The major crops grown in the district are maize, finger millet, teff, wheat, barley, potato, pepper, onion, field pea and fava bean. The types of livestock reared in the district include cattle, shoat, equine and chicken. Guagusa Shikudad district has a total of 211,929 livestock population with 17,112; 69,914; 35,846 and 89,057 equine, cattle, shoat and chickens, respectively. The district has 21,822 and 594 dairy local and cross breed cows, respectively. From these, 10,150 cows are lactating local, and 315 cows are lactating crossbred cows (GSDARDO [Guagusa Shikudad District Animal Resource Development Office], 2021).

The district has different feed resources used for feeding of different species of animals, mainly crop residues, natural pastures, cultivated pastures and non-conventional feed resources or house hold wastes. Bamboo is one feed source in the area in dry season but the utilization of this feed resource is not common. Farmers cannot use this feed resource as animal feed properly because of the frustration of problems of bamboo leave to cows' health and lack of awareness; but when they cut the tree for other purposes, animals feed at that time. The feeding systems in the area include free grazing, partial grazing, tethering and rarely indoor feeding for crossbred cows systems.

2.2 | On-farm evaluation of bamboo leaves supplementation on lactating cows' performance

Feeding trial was conducted to determine the effect of bamboo leaves supplementation on milk production performance, milk composition and body weight of dairy cows. From 232 total crossbred cows population in selected PAs, only 20 cows were in the first stage of lactation and second parity. Among them, 12 dairy cows were selected using a simple random sampling technique for an on-farm feeding trial. The feeding experiment was conducted in three neighbouring Pas, namely Askuna, Jibayta and Agiza.

The daily milk production performances of individual experimental dairy cows' data were recorded using data recording formats. Monitoring of milk yield of individual cow was carried out for 45 days after 15 days of adaptation. The milk yield data was collected by trained enumerators who are living within the community of PAS and supervised by the researcher. Enumerators in each PA were recruited and trained by the researcher on how to record the daily milk yield and feeding cows properly based on the recommended treatment levels.

2.2.1 | Experimental design and treatments

A Randomized Complete Block Design with three treatments and four blocks was used based on dairy cows initial body weight. That is, four crossbred cows having related body weight were assigned in each block. The experimental animals were allotted to one of the three dietary treatments randomly using lottery system.

2.2.2 | Feeding trial feed preparation

Enough amounts of highland bamboo leaves for feeding trial were collected from each PA. Highland bamboo leaves were collected based on bamboo availability and accessibility. Collected highland bamboo leaves were dried, chopped and treated with urea molasses. The high-land bamboo leaves were treated with a urea-molasses solution prepared from 40 g of urea per kg of straw dissolving it in 800 mL of water, and then 100 mL molasses were added in the solution of urea that were stirred well (Ibrahim & Schiere, 1989). A uniform spray of urea-molasses solution was applied on highland bamboo leaves. It was treated and compacted until filled to the ensiling bag capacity. Finally, the bags were made airtight and left unopened for 21 days. By the end of the treatment period, the plastic bags were opened, and a portion of the highland bamboo leaves hay were taken daily and ventilated overnight to remove residual ammonia before offering to the animals.

2.2.3 | Experimental animals and feeding management

Experimental cows were tested against mastitis by collecting milk samples from each quarter of the cow's udder using California Mastitis Test and dewormed for internal parasites with Albendazole (one bolus per 250 kg body weight) prior to the start of the experiment. The treatment diet was given to cows individually for a period of 45 days and an adaptation period of 15 days. The initial and final body weights of the dairy cows were estimated using heart girth measurements. The experimental dairy cows' initial average body weight and initial milk yield were (328.08 ± 0.98 kg), (3.14 ± 0.78 L), respectively. Body weight changes were recorded at the beginning and end of experiment for each treatment to monitor body weight changes across periods for each dietary treatment.

The experimental cows were allowed to graze for 6 h as practiced by farmers, and treated and untreated highland bamboo leaves (UHBL) were offered ad libitum. The amount of concentrate supplements to experimental dairy cows considering NRC (2001) for milk production of 10-L/day body weight of the lactating cows within 350–400 kg body weight and 3.5%–4% fat-corrected milk (See Table 1). Water was given ad libitum for all experimental animals throughout the experiment. Common salt was also freely available for dairy cows for licking. Samples offered from treated UHBL and refusals were collected daily, weighed and bulked in 45 days for chemical analysis. The daily dry matter and nutrients intake were calculated by the difference of feed offered and left over. Calves were allowed to suckle until the stimulation of the udder milk let down. All crossbred dairy cows were hand milked twice a day (in the morning at 7:00 AM and in the evening at 7:00 PM). After milking, milk yield of individual dairy cows was weighed by using 1 L milk holding capacity calibrated plastic container which was available in every household locally known as plastic jug. Milk yield measurements were taken at the start of the experiment and during the entire study period of 45 days.

TABLE 1 Experimental treatments.

Description	Treatments	Feeding levels
T1	Grazing (control)	Six grazing hours + 4 kg concentrate
T2	Control + urea molasses treated BL	Ad lib + six grazing hours + 4 kg concentrate
T3	Control + untreated BL	Ad lib + six grazing hours + 4 kg concentrate

Abbreviation: BL, bamboo leaves.

2.2.4 | Chemical composition of milk

About 15 mL milk samples using milk test tube were collected from each experimental cow fortnightly at each milking time (7:00 AM and 7:00 PM) after the whole milk thoroughly mixed. The pooled milk samples per cow were kept in an ice box and delivered to Biotechnology Laboratory where the milk analyser lactoScan (Milkotronic Ltd.) machine was available. Milk samples were analysed for milk composition parameters such as fat content, protein content, solid-not-fat, ash, density, temperature, adulteration, freezing point and lactose.

2.2.5 | Chemical composition of experimental feed

Samples of feed offered and left over were collected every morning during 45 days of experiment for chemical analysis. Feed samples were oven-dried at 60°C for 48 h at animal nutrition laboratory. Then, the dried samples were ground using a hammer mill to pass a 1 mm screen for DM, OM, N analysis (AOAC [Association of Official Analytic Chemistry], 1990). The CP was calculated = $N \times 6.25$. Fibres (neutral detergent fibre [NDF], acid detergent fibre [ADF] and acid detergent lignin [ADL]) were analysed according to Van Soest and Robertson (1985).

2.2.6 | Partial budget analysis

For partial budget analysis, all feed costs associated with highland bamboo leaves ensiling were added to total variable cost (TVC). The cost of grazing and concentrate feed supplementation for all treatment groups was not considered because these variable costs were the same for the entire treatment groups. The income from the sale of milk was recorded as per the market price in that time. The net return (NR), that is, the amount of money left when TVCs are subtracted from the total returns/income (TR): NR = TR − TVC.

TABLE 2 Chemical composition of experiment feeds.

		UHBL		UMTHBL	
Measurements	Concentrate	Offer	Refusal	Offer	Refusal
DM (%)	92.53	91.91	91.72	91.55	91.51
Ash (%)	9.84	10.32	10.27	12.45	12.41
CP (%)	26.38	14.33	13.89	16.98	16.48
NDF (%)	47.65	73.44	81.17	68.21	72.89
ADF (%)	22.59	47.90	54.50	43.20	46.58
ADL (%)	4.28	10.71	11.29	9.58	10.35
OM (%)	90.26	89.69	89.89	87.75	87.65

Abbreviations: UHBL, untreated highland bamboo leaves; UMTHBL, urea-molasses-treated highland bamboo leaves.

2.3 | Data management and statistical analysis

All on-farm feeding trial collected data, such as milk yield, body weight and milk composition, were analysed through the analysis of variance (ANOVA) using statistical analysis software (version 9.4). When ANOVA declares significant, mean separation was done using LSD test at $p < 0.05$.

The statistical model used was as follows:

$$Y_{ijk} = \mu + T_i + B_j + e_{ijk}$$

where Y_{ijk} is the dependent variable (milk yield, milk composition, body weight). μ is the overall mean. T_i is the effect of the ith experimental diet. B_j is the effect of the jth blocking. e_{ijk} is the random error.

3 | RESULTS AND DISCUSSION

3.1 | Chemical composition of experimental feed

The chemical composition of treatment feeds offered to experimental cows is presented in Table 2. The result of this study showed that organic matter content of the UMTHBL was lower than UHBL. This is in line with the result of Kebede (2009) in urea-treated wheat straw and Adugna et al. (2020) in urea-treated lowland bamboo leaves hay. The mean CP content of UMTHBL is higher than that of the UHBL, indicating that urea treatment enhanced the CP content of highland bamboo leaves hay by 18.5% which is lower than the values reported by Asmare et al. (2020) for rice straw CP by 46.016% and Adugna et al. (2020) for low land bamboo leaf hay CP by 37%. The deviation of the current results from the previous findings might be attributed by cultivars or species of bamboo, harvesting stage or age of bamboo leaves, environment where the ensiling carried out and amount of urea added.

The OM and CP contents of UHBL in this study were comparable to the results of Eyob (2016) (80.7% OM and 20.5% CP), Mekuriaw et al. (2011) (81.5% OM and 11.1% CP) and Adugna et al. (2020) (87.7% OM and 15.87% CP). The CP contents of UHBL and UMTHBL diets were higher than CP required for microbial protein synthesis in the rumen (above 7%) that can support at least the maintenance requirement of ruminants as reported by van Soset (1994) and McDonald et al. (2010). In terms of fibre fractions, an application of urea-molasses treatment in the current study reduced the fibre (NDF, ADF and ADL) content as expected; this is in line with the result of Adugna et al. (2020) who reported for fibre reduction because of treatment for lowland bamboo hay and Asmare et al. (2020) reported for fibres reduction in urea-molasses-treated rice straw.

The refusal CP content decreased, whereas the fibres content increased as compared to the offered feed because of the selection ability of dairy cows to better nutritive value and palatable parts. This is in line with the result of Tekliye et al. (2018) who reported the reduced CP and ash content of the refusal sample of urea-treated rice straw and increased fibres content.

3.2 | Dry matter and nutrient intake

The daily dry matter and nutrient intakes of cross bred dairy cows fed basal diets of UHBL and UMTHBL supplemented with concentrate feed are presented in Table 3. The result indicated that UMTHBL performed better than the UHBL in terms of total dry matter, organic matter, CP, NDF, ADF and ADL. This is in line with the results of Adugna et al. (2020) who reported that there was more nutrient intake of sheep fed urea-molasses-treated lowland bamboo leaves than the untreated ones. The improved nutrients intake recorded in T2 because of the better palatability of UMTHBL. Similar results were also reported (Eshetie et al., 2012) that the supplementation of urea-molasses block increased nutrient intake of cross-bred dairy cows. Feeding UMTHBL in the current study was found to improve DM intake (11.47 kg/day, compared to untreated bamboo leaf hay (9.53 kg/day). This result is in agreement with the finding of Derso (2009) who reported an increased dry matter intake of cross-bred dairy cows fed urea-treated wheat straw in Fogera district, and feeding urea-treated teff straw was found to improve straw DM intake, compared to untreated teff straw in Lume district, respectively.

TABLE 3 Daily dry matter and nutrient intakes of cross bred cow fed basal diets of untreated and treated highland bamboo leaf hay and supplemented with concentrate dairy cow feed (based on half of their daily milk yield).

Treatment	TDMI (kg)	TCPI (kg)	TNDFI (kg)	TADFI (kg)	TADLI (kg)	TOMI (kg)
T1	1.73[c]	0.45[c]	0.82[b]	0.38[b]	0.07[b]	1.55[c]
T2	11.47[a]	2.14[a]	7.73[a]	4.51[a]	0.97[a]	10.06[a]
T3	9.53[b]	1.62[b]	6.85[a]	4.03[a]	0.89[a]	8.56[b]
Overall mean	7.57	1.40	5.13	2.97	0.64	6.73
SE	0.95	0.16	0.81	0.42	0.10	0.87
CV	12.59	11.73	15.72	14.03	15.63	12.90
p-Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
SL	***	***	***	***	***	***

Note: Different superscripts (a–c) in the column indicate significant ($p < 0.001$) differences. T1: grazing + concentrate; T2: grazing + urea-molasses-treated bamboo leaves + concentrate; T3: grazing + treated bamboo leaves + concentrate.
Abbreviations: CV, coefficient variation; SL, significance level; TADFI, Total acid detergent fibre intake; TCPI, total crude protein intake; TDMI, total dry matter intake; TNDFI, total neutral detergent fibre intake; TNDLI, total neutral detergent lignin intake; TOMI, total organic matter intake.
***$P < 0.0001$.

TABLE 4 Body weight change of cross bred cow fed basal diet of treated and untreated highland bamboo leaf hay; and control and supplemented with dairy cow concentrate with half of their milk yield.

Treatment	Initial body weight (kg)	Final body weight (kg)	Body weight change (kg)
T1	326.00[a]	323.00[a]	−3.00[b]
T2	340.00[a]	341.25[a]	1.25[a]
T3	318.25[a]	317.5[a]	−0.750[ab]
Overall mean	328.08	327.25	−0.83
p-Value	0.77	0.73	0.048
CV	12.96	13.30	−244.95

Note: Means with different superscripts (a, b) within columns are significantly different ($p < 0.05$); T1: grazing + concentrate; T2: grazing + urea-molasses-treated bamboo leaves + concentrate; T3: grazing + treated bamboo leaves + concentrate.
Abbreviation: CV, coefficient variation.

3.3 | Body weight change of experimental dairy cows

The body weight change of cross bred dairy cows fed basal diet of UMTHBL and UHBL supplemented with dairy cow concentrate feed is presented in Table 4. Significantly higher ($p < 0.05$) weight gain was recorded in T2 (1.25 kg) compared to T3 (−3 kg) and T1 (−0.75 kg). The better in body weight gain of T2 in the current study could be associated with a better intake of CP and organic matter. The result agrees with the result of Kumssa and Eshetu (2018) who reported the better body weight gain in urea-treated *teff* straw fed dairy cows at on-farm study and Kebede (2009) who reported that treated wheat straw improved body weight gain, whereas the untreated wheat straw recorded weight loss for dairy cows at on-farm study in Bure district. Contrarily, Kitaw et al. (2022) reported body weight changes of cows remained unaffected ($p > 0.05$) as compared to cows fed bamboo leaves and natural pasture hay. In contrast, weight loss in lactating cross bred dairy cows fed on treated rice straw was reported in Fogera District (Derso, 2009).

3.4 | Milk yield and composition

Results of the effect of dietary treatments on the average daily milk yield ($p < 0.05$) and compositions are presented in Table 5. In the current study, a significant difference ($p < 0.05$) was obtained for daily milk yield, whereas a non-significant ($p > 0.05$) difference was recorded for almost all chemical compositions of the milk. The UMTHBL fed dairy cows produced significantly more milk ($p < 0.05$) than those group of dairy cows grazed on natural pasture alone and group of dairy cows fed untreated bamboo leaves. In the current study, still the dairy cows fed on UHBL could produce more milk yield than the dairy cows' unfed bamboo leaves. Similar results were also reported by Dejene et al. (2009) and Kitaw (2008) who reported for crossbred dairy cows fed on urea-treated teff and wheat straw, respectively. This could be supported with the finding by Jo et al. (2022) who reported that bamboo leaves reduced methane emission by reducing methane which otherwise losing metabolisable energy useful for milk production. Regarding the milk composition of the current study, Kitaw et al. (2022) who similarly reported that bamboo leaves feeding did not change dairy cows' milk composition except for milk fat. The implication of the study is that increasing the volume of milk production could fill the milk demand, and smallholder farmers could improve their livelihoods.

Similar to the current study regarding milk composition, Getu (2008) reported non-significant difference ($p > 0.05$) for milk fat and milk protein in urea-treated wheat straw fed dairy cows, but contrast with Kebede (2009) who reported that the fat content of milk was higher ($p < 0.05$) for treated straw than untreated straw.

TABLE 5 The effect of dietary treatments on the average daily milk yield and compositions.

Treatment	Mean yield (L/day)	Milk composition (%) Fat	SNF	Density	Protein	Lactose	Added water	*T* (°C)	PH	FP	Ash
T1	3.27[b]	4.79	6.83	20.96	2.40	3.59	17.25	23.81	7.89[ab]	0.41	0.54
T2	6.26[a]	4.07	7.51	22.41	2.53	3.78	14.84	24.71	7.95[a]	0.43	0.56
T3	4.44[b]	4.63	6.66	22.54	2.57[a]	3.68	13.38	23.61	7.88[b]	0.43	0.57
Overall mean	4.66	4.49	6.99	21.97	2.50	3.68	15.16	24.04	7.91	0.42	0.56
SED	0.51	1.09	1.52	3.66	0.28	0.43	9.56	2.46	0.08	0.05	0.07
CV%	21.87	24.17	21.76	16.67	11.33	11.62	63.09	10.24	0.99	12.89	12.12
p-Value	0.007	0.76	0.26	0.40	0.20	0.45	0.51	0.41	0.03	0.35	0.55

Note: Means with different superscripts (a, b) within columns are significantly different ($p < 0.05$); T1: grazing + concentrate; T2: grazing + urea-molasses-treated bamboo leaves + concentrate; T3: grazing + treated bamboo leaves + concentrate.
Abbreviations: CV%, coefficient of variation; FP, freezing point; SED, standard error of difference; SNF, solid-not-fat; *T*, temperature.

TABLE 6 Partial budget analysis of treatment diets.

Costs and benefits	Feed treatments		
Cost of feeds and milk (ETB)	T1	T2	T3
Cost of bamboo leaf treatment (ETB) Cost of urea (ETB)	–	120	–
Cost of plastic (ETB)	–	150	–
Cost of molasses	–	200	–
Cost of labour (ETB)	00	100	100
Total variable cost	00	2280	400
Cost/cow/experimental period (ETB)	00	570	100
Cost/cow/day (ETB)	00	12.66	2.22
Mean kg of milk per treatment per day	3.27	6.26	4.44
Cost/cow/kg of milk (ETB)	00	2.02	0.50
Gross income from sale of milk/treatment/day (ETB)	98.1	187.8	133.2
Net profit (ETB)	98.1	185.78	132.7
Net profit over the control/ treatment/day (ETB)	–	87.68	34.6

Note: T1: grazing + concentrate; T2: grazing + urea-molasses-treated bamboo leaves + concentrate; T3: grazing + treated bamboo leaves + concentrate. One litre of milk was an average value of 30 ETB in the district.
Abbreviation: ETB, Ethiopian birr.

3.5 | Partial budget analysis of dairy cows fed urea-molasses-treated highland bamboo leaf

The dairy cows fed on UMTHBL recorded the highest net profit with Ethiopian birr (ETB) ETB 185.78/cow/day followed by dairy cows fed on UHBL (ETB 133.2/cow/day) (Table 6). The least net profit (98.1/cow/day) recorded from dairy cows grazing alone. This means that if the farmers do not have an access to the chemical treatment technologies in the area, still feeding the untreated highland bamboo for dairy cows could get profit. Small holder farmers could be benefited sustainably from the bamboo plant because it is an ever green and available in dry season, whereas other feed resources are scarce. In this regard, it is worth mentioning that the variable cost incurred during the ensiling process can even be minimized by looking for alternative ensiling facilities could be made from locally available resource.

4 | CONCLUSIONS

The on-farm evaluation of UMTHBL leaves in the crossbred dairy cows reflected in a better nutrient intake, improved milk yield, body weight and NR. Though milk fat was not significantly different, numerically better fat was reflected in dairy cows fed on UMTHBL. Milk fat is an important trait the farmers prefer for butter making. As a conclusion, employing urea-molasses treatment technology for highland bamboo leaves could support sustainable crossbred dairy cow production in smallholder farmers.

AUTHOR CONTRIBUTIONS

Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; validation; visualization; writing – original draft; writing – review and editing: Semahegn Tirusew. *Conceptualization; methodology; resources; supervision; writing – review and editing*: Yeshambel Mekuriaw. *Conceptualization; funding acquisition; project administration; resources; supervision; writing – review and editing*: Abule Ebro. *Conceptualization*: Adolfo Alvarez Aranguiz and Jan van der Lee.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest among the authors.

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ETHICS STATEMENT

Bahir Dar University has established ethical clearance committee, but the experimental protocol document is not yet established. This experiment had strictly followed to the established experimental procedures. Directive 2010/63/EU of the European Union guidelines (2010) concerning the treatment and use of animals in research and development purposes were employed.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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