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Characterization of Dairy Farms, Farmers' Training and On-Farm Evaluation of Urea-Treated Straw and Urea-molasses-block (UMB) feeding on Performances of Lactating Crossbred cows in Ada District of East Shoa Zone, Ethiopia

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Abstract: This work aimed to characterize the urban and peri-urban dairy farms, train farmers and extension staffs on straw-urea treatment and UMB making and evaluate them, as fed to lactating cows, on milk yield and composition and economic benefits. A semi-structured questionnaire was prepared and pre-tested and 76 smallholder dairy farms were interviewed. Three feeding regimes were tested on-farm: T1- farmers' practice (control), T2-urea treated tef straw *ad lib* + concentrate, and T3- (Untreated tef straw + UMB) *ad lib* + concentrate. A total of 208 participants received training on straw urea-treatment and UMB making, of which 196 were farmers (female-15.8%, male- 82%) and 12 were extension agents and experts. Over 31% of the surveyed households (HH) were female-headed, while the average family size (persons/HH), age of household-head (year) and illiteracy rate (%) was 6.02, 43.42 and 10.8, respectively. Most households owned 1-8 cows in milk, 0-6 dry or pregnant cows and 0-5 calves. The cows were stall-fed and milked twice a day. The available feed resources were crop residues, natural pasture and concentrates. All farms purchased concentrate feeds, but roughages were often purchased by urban dairy farms as opposed to peri-urban farms that produced them on-farm. Small proportions of peri-urban farms produced forage crops, where irrigation scheme is available. The major production challenges were:feed shortage (100%), high feed cost (97.15%), prevalence of diseases and parasite (65%), inadequate AI service (44.78%) and inaccecibility to market for product (7.4%). The average daily milk yield per cow was increased by 28.24% (2.46 liter) in T2 and by 24.22% (2.11litre) in T3 over the control (T1). The net profit of production per farm was increased by 487.07 (T2) and 112.13 ETB (T3) over the farmers' practice. Farmers' perception on the transferred technologies was positive. It was concluded that the intervention diets contribute significantly to the development of smallholder dairy farms and need to be further demonstrated on-farm in wider scale.

Key words: Dairy cows · Urea-molasses-block · Straw treatment · On-farm

INTRODUCTION

Despite the presence of large livestock population and high demand for animal products in Ethiopia, the livestock production system in general and the dairy sub-sector in particular are underdeveloped and characterized as low input-output system. Indigenous breeds accounted for 98.2% of total cattle population, of which 7.2 million are used exclusively for milk production [1]. The national average milk yield per cow was only 1.37 liters/day with average lactation length of 6 months [1]. However, there is a rapid increase in demand for the dairy products (milk, butter, cheese) driven by increasing human population, urbanization and income. Per capita milk consumption has declined from 26 liters per annum in 1980 to 16 liters in 2009, ranking Ethiopia one of the least countries in the world [2].

Improved dairy cattle production systems are operating in and around the capital and regional towns of the country, taking the advantages of access to inputs and services such as concentrates feeds, AI services and markets for the product [3]. However, various production challenges have been contributed to the underdevelopment of the sector: inadequate technologies, limited supply of inputs, poor extension service and its limited supports by research, high incidence of disease

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and parasite and poor marketing. Hence, technology and knowledge transfer to smallholder farmers worth attention to bring a radical change in the sector development.

Feed deficit (low quality and quantity), its high cost and poor feeding system remain notable challenges, impairing the productivity and profitability of dairy farms. In Ethiopia, most available dry roughages contain 6.2% CP and 7.5 MJ ME/kg DM with potential IVOMD of about 50.4%, supporting little of dairy cows maintenance requirement [4]. Normally, feed supply shortage is about 35%, which may rise to 70% with drought occurrence [5]. Reduced pasture lands and unimproved management, low dissemination and adoption of forage technologies due to land and seed scarcity have led to low availability of high quality feeds.

Urea-treating of poor quality roughage and UMB making has been widely used as a strategy to improve rumen microbial fermentation and animal performances [6-12]. Also, they are cost-effective options for smallholder farmers to improve the nutritive quality of on-farm available feeds and reduce the level of concentrate consumption. However, in Ethiopia, most on-station generated technologies and management options have not widely verified on-farm for their performances and acceptance by farmers. Therfore, this work aimed to characterize dairy cattle farms, to train farmers on straw-urea-treatment and UMB making and evaluate feeding them to lactating crossbred cows on milk yield, milk composition and economic benefits.

MATERIALS AND METHODS

Description of the Areas: The studies and farmers' training were carried out in Ada district, located South East of Addis Ababa, in East Shoa Zone of Oromia Region, Ethiopia. The district has a total area of 675 km^2 and found between 38°53'16" E; 39°18'39.3" E and 8°39'13.5" N; 8°52'8.9" N. The altitude ranges 1600-2914 meter above sea level. The mean annual rainfall, minimum and maximum temperatures are 839 mm, 7.9°C and 28°C, respectively [13]. The area receives a bimodal rainfall where the small rainy season is between March and April and the main rainy season between July and September. The major crops grown are Tef (*Eragrostis tef*), wheat, chick pea, lentil and barley.

Survey Study: The study targeted the dairy cattle farms operating in and around Bishoftu town. Three sub-towns (kebeles) and six nearby peasant associations (PA): Denbi, Kurkura, Babogaya, Ude, Dankaka and Godino were selected purposely based on dairy farm holdings and accessibility (Figure 1). List of households (dairy farms)

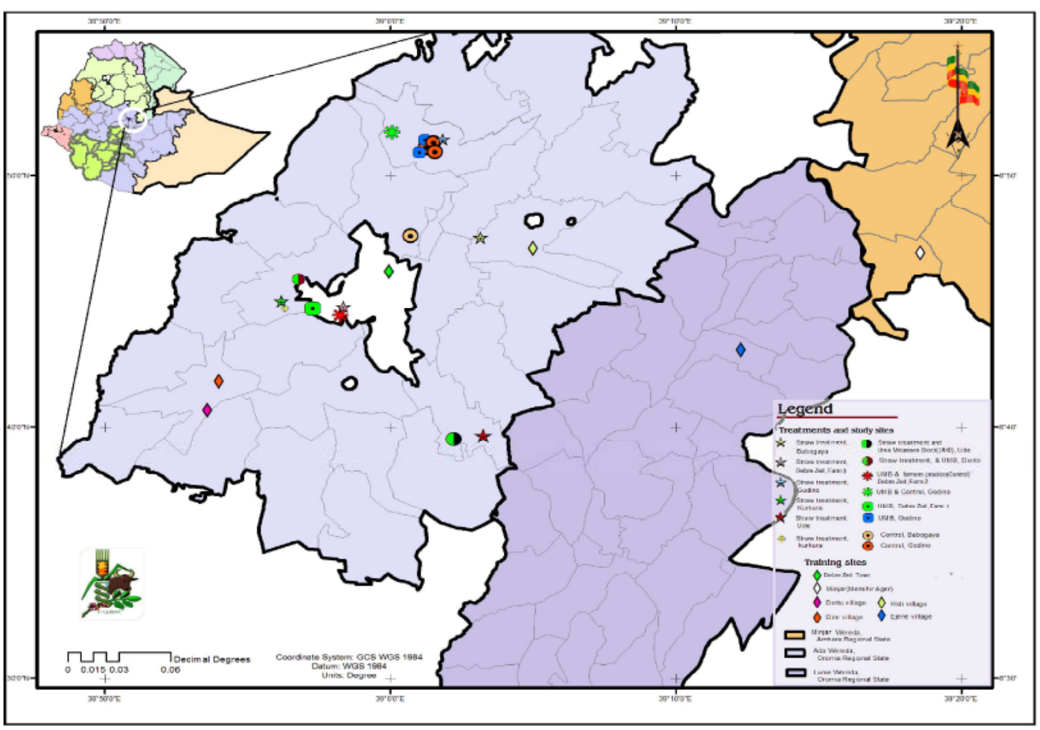

Fig. 1: Map of the study and training areas

was obtained from Ada District Agricultural Office. A total of 67 households owning crossbred dairy cattle (Local zebu x *Holstein Friesian*) were randomly selected for interview from the list obtained proportional to their number. A survey questionnaire addressing family size, education level, dairy stock size and structure, feeds and feeding of dairy cows was prepared and pre-tested before data collection. Data was enumerated by trained development agents (DA) and researchers.

Training: Dairy farm household heads, extension agents and experts were recruited and trained on straw urea treatment, UMB making and feeding management at six locations (Debre Zeit town, Minjar, Ejerie, Dire, Dertu and Hidi) (Figure 1). Training manuals and leaflets were prepared and inputs such as urea, molasses, molder, barrels and jogs were purchased. At each training site, the theoretical training sessions were held at Farmers' Training Centers (FTC) and in schools, while demonstrations were on one of the participant's farm. The training at Debre Zeit station involved farmers from Denbi, Kurkura, Babogaya, Ude and and Godino. A total of 208 participants (196 farmers: female- 15.8%, male -82%; 12 DA: male- 50%, female-50%) received training.

Feeding Trial: At the end of training session, research participatory farmers (households) were selected based on their similarities in the dairy cattle breed owned (*Local zebu x Holstein Friesian*), stage of lactation of cows in milk (5-8 weeks after calving), parity (1st to 2nd), feed resource availability and willingness to implement the research. Accordingly, a total of 30 households (11 female-headed and 19 male-headed) were selected and trained on proper implementation (feeding cows, data collection, recording and sampling) of the following feeding regimes.

Treatments	Feeding level
1. Farmers' practice (control)	----
2. UTS* + concentrate	Tef Straw *ad lib*+ concentrate @0.5kg/litre of milk yield
3. UMB** + concentrate	Untreated straw *ad lib* + concentrate@0.5kg/litre of milk

*=urea-treated straw, **= Urea-molasses-block

Ten experimental cows were randomly assigned per treatment, where a household received at least a dietary treatment for implementation. All cows were dewormed using Albendazol (2500 mg/cow) and data were taken on initial live weight (using a weighing band), milk yield and body condition scores (BCS: 1-5 scale: 1= very thin, 5=very fat).

Experimental Feed Preparation: A pit with dimension of 2m-length x1m-width x 1m depth was prepared on the farms received T2. Straw was treated with a solution prepared from 5 kg urea (fertilizer grade) per 100 kg of straw (straw: water = 1:1). Molasses was added at 10% of straw used. Ten kg of straw was treated at each batch, soaking with proportionate amount of solution and compacted by trampling it in the pit using group of farmers. Finally, the pit was airtight, by covering with polyethylene sheet and loading a mass of soil on top. It was opened after 21 days of ensiling.

Adequate number of UMB, weighing 5 kg each, was produced, on each farm receiving T3, from a mix containing 40% molasses, 25% wheat bran, 10% noug seed cake, 10% urea, 10% cement and 5% salt. Water was added at 4% of the mix by weight. The blocks were produced using a mica mold and air dried under shade for 7 days before use. Similarily, the concentrate mix was prepared from 74% wheat bran, 25% noug seed cake and 1% common salt.

The amount of concentrate fed to a cow (T2 and T3) was at a rate of 0.5 kg per liter of milk yield and supplemented twice daily during milking. Cows in control group (farmers' practice) fed home-made concentrates and tef straw, which were more or less similar for the selected farms. They concentrate mix of different ingredients (bran, oilseed cakes, dried poultry litter and cage excreta, brewery residues). The new diets were gradually introduced to cows elapsing 15-20 days of adaptation, followed by data collection for 45 days. The straw was offered *ad libitum,* ensuring adequate refusal while the consumption of UMB was allowed by licking. Water was freely available for each cow.

Data Collection and Laboratory Works: Three local development agents were involved in monitoring and data collection. Each farm was also followed-up by the researchers twice a week. Feed refusal was collected from each cows' trough the following day morning, weighed, stored and sub-sampled. Cows were milked twice daily at 6:00 am and at 4:00 pm. Live weight and body condition score (BCS) were measured biweekly. Milk was sampled per cow biweekly and placed in a portable ice-box until taken to lab for chemical analysis. The prevailing market price of inputs used and milk was assessed and recorded.

Feed samples were analyzed for dry matter, ash, crude protein [14], neutral detergent fiber (NDF) and acid detergent fiber (ADF) and acid detergent lignin (ADL) [15]. Milk fat, protein, solid not fat, total solid, lactose and density were analyzed using EKOMILK TOTAL Ultrasonic Milk Analyzers [16].

Statistical Analysis: Data were subjected to statistical analysis using GLM procedure of SAS [17]. Initial milk yield was used as a covariate in analyzing milk yield and milk composition. When, ANOVA declares significant, treatment means were separated using LSD (P=0.05). Descriptive statistics was used to summarize survey data.

RESULTS AND DISCUSSION

Characteristics of Survey Households: The proportion of female-headed households engaged in dairying was higher for urban (56%) than peri-urban (24%) farms that might be related to differences in the property ownership right among the household spouses in the two systems. The average family size of the study area ranged 1 - 12 persons/HH (mean = 6.02), of which 49.5% were male family members. The average age of the respondents was 43.42 years (range: 22-80), and most of them were educated with relatively lower illiteracy rate (10.8%) (Table 1).

Herd Composition, Milk Yield and Breeding Methods: According to the respondents, all farms owned Boran x *Holstein Friesian* crosses with exotic blood level above 50%. With the exception of a peri-urban farm that owned 23 dairy cows, most farms owned 1-8 cows in milk, 0-6 non-lactating cows and 0-5 calves (Table 2). The cows were entirely stall-fed and milked twice daily in the morning and late in the afternoon. The average daily milk yield of a cow was significantly (P<0.01) higher in urban- than per-urban farms that could be associated with differences among cows' parity, blood level, stage of lactation and level of management. The majority of households (>80%) of the study area bred their cows using AI service provided by private inseminators.

Feed Resources and Nutritional Quality: Feed resources used by the dairy farms were alike (Figure 2). Tef straw and wheat straw were major basal diets used in interveiwed farms. Also, natural grass hay was important feed, particularly in urban dairy farms that purchased it from feed traders. All dairy farms (100%) used purchased concentrate (wheat bran, wheat middling, noug seed cake, lin seed cake, maize grain, molasses and common salt), while about 92% of the peri-urban farms used home-made concentrates (wheat bran, poultry litter, brewery residues and salt). Concentrate feeds were supplemented to lactating cows twice a day at milking times. The roughage part was offered *ad lib* along with tap and/or well water. Local brewery residues (*tela atela*) and air dried poultry litter were used by over 50% of farms and fed by mixing them with straw and concentrate. Fodder crops such as oat, vetch, alfalfa *(Medicago sativa*), Rhodes grass, Elephant grass, leucaena and sugarcane were grown in Godino, where irrigation scheme is available. However, their scale of production and contribution to livestock feedstock was scant. The urban dairy farms obtained roughage feeds by purchasing as opposed to majority (80%) of the peri-urban farms that produced them on-farm.

Table 1: Demographic status of male- and female-headed households interviewed in the study areas

	No. of respondents			Family size/HH				
Production system	Male	Female	Total	Male	Female	Total	Age (year)	Education level
Urban*	7	9	16	2-4	2-8	3-12	40-70	Illiterate (10.8%), primary to junior (41.5%),
Peri-urban**	39	12	51	1-7	1-7	1-10	22-80	High school (35.4%) and tertiary (12.3%)
Total	46	21	67	1-7	1-8	1-12	22-80	

* = Bishoftu town (3 sub-towns); ** = PA (Babogaya, Kurkura, Denbi, Godino, Ude, dankaka)

Table 2: Dairy herd composition, average milk yield of cows and breeding service used in urban and peri-urban areas of Bishoftu town

Measurements	Urban (n=16)	Peri-urban (n=51)	Total (n=67)
Dairy stock size per HH (range)			
Cows in milk	2-8	1-23	137
Dry/pregnant cows	0-2	0-6	50
Calves	1-5	0-13	80
Milk yield (litre/cow/day, mean+se)*	11.2± 0.73^a	7.4±0.78^b	8.3±0.60
Breeding service (% of respondents)			
AI	81.2	83.7	83.1
Bull	18.8	16.3	16.9

n= number of households (HH); se = standard error of means; AI = artificial insemination; *: P<0.05

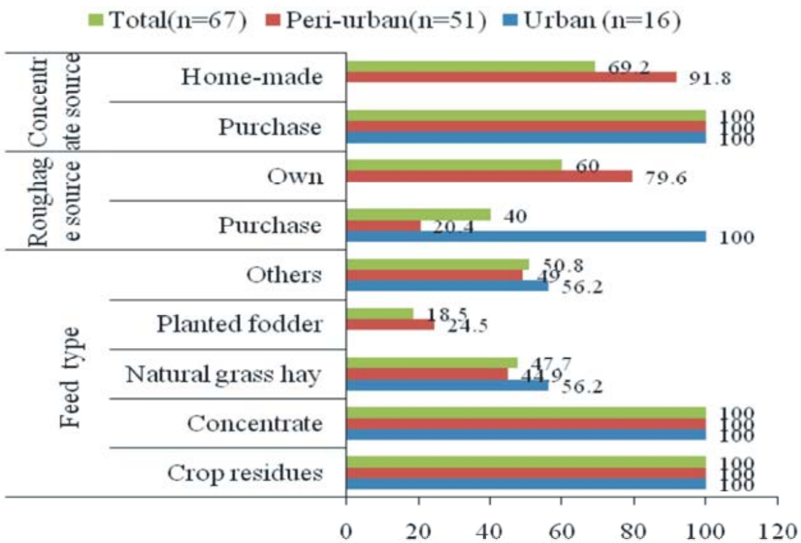

Fig. 2: Percentage of farm households indicating feed resources used and their sources

Table 3: Chemical composition (%DM, except %DM) of feed samples used by smallholder dairy farms and urea-treated straws.

Feed type	DM	CP	ASH	NDF	ADF	ADL
Wheat bran	91.80	15.90	9.46	40.60	9.13	2.13
Wheat middling	92.90	16.50	5.88	26.40	10.00	1.60
Noug (*Guzotia abssinica*) seed cake	93.50	31.40	9.99	29.90	20.20	10.60
Cotton seed cake	92.30	37.80	12.01	20.75	10.40	3.50
Lin seed cake	93.25	27.60	13.08	24.40	16.90	5.20
Maize grain	91.30	10.30	13.62	10.30	1.20	0.00
Mill house byproduct	91.80	16.80	11.63	15.00	6.60	1.20
*Concentrate mix	92.87	23.20	6.71	37.60	9.63	2.67
Oat hay	92.90	8.20	9.41	68.00	32.20	7.60
Field pea haulm	91.70	7.20	10.66	63.80	37.80	9.40
Poultry litter	90.60	21.04	5.96	40.30	12.60	3.60
Tef straw	93.23	4.02	7.40	69.50	39.00	9.47
Urea-treated tef straw	51.50	7.83	6.50	67.60	37.13	10.80
Wheat straw	93.23	3.20	8.10	61.53	41.85	8.88
Urea-treated wheat straw	51.50	8.10	8.50	66.07	38.97	13.67
Brewery residue *(Tela Atela)*	15.01	20.70	4.50	53.05	34.03	10.20

DM=dry matter; CP= crude protein; ADF =acid detergent fiber; ADL=acid detergent lignin;
NDF = neutral detergent fiber, * prepared by farmers

The nutrient contents of feedstuffs available on-farm varied, showing a potential for use and improvement (Table 3). Oil seed cakes had higher crude protein (CP=27.6-37.8%), but lower in (NDF: 20.75-29.9%). However, the roughages had lower CP (3.2-8.2%), but higher NDF (61.53-69.5%). The CP content of urea-treated straw was nearly double that contained in untreated straw (4.02 *vs.* 7.83%), while that of wheat straw increased from 3.2 to 8.1% CP. The fraction of ADF was lower in the treated straws, while NDF decreased in treated tef straw, indicating delignification and release of soluble carbohydrates. Improvements in the nutritional qualities of urea-treated straws were also reported by other scholars [10, 11, 12].

Production Constraints as Perceived by Farmers: The major production challenges of the dairy farmers were feed shortage (100%), high feed cost (97.15%), inadequate AI service (44.78%), prevalence of diseases and parasite (65%) and inaccecibility to market for products (7.4%). Feed deficit had been a critical problem, particularly during dry season. Feed shortage have been dramatically increasing in recent years, leading to withdrawal of most farms' from operation and/or reduced number of animals raised on farm. The expansion of cropping has severely reduced pasture lands, but favored crop residues as a major feed resource in the study areas. In agreement with the present results, inadequate nutrition and feed supply have been reported as a major constraint in traditional livestock farming of Ethiopian [18, 19, 20].

Table 4: Feed DM and nutrient intake (Kg±SE), live weight change and BCS of experimental cows

	Treatments			
Parameters	Farmers' practice	With UMB	Urea-treated straw	*P*- value
Straw DMI	5.039 ±0.095c	7.055±0.086a	5.966±0.076b	<0.001
Straw CPI	0.182± 0.005c	0.262± 0.004b	0.4763±0.004a	<0.001
Concentrate DMI	4.313± 0.080c	6.004±0.075a	5.325± 0.066b	<0.001
Concentrate CPI	0.751± 0.016c	1.244± 0.015a	1.061±0.013b	<0.001
UMB DMI, g/day	-	506.5±2.42	-	-
Poultry litter DMI	0.989± 0.05	-	-	-
Poultry litter CPI	0.208±0.01	-	-	-
Total DMI	10.34± 0.15c	13.56± 0.13a	11.29± 0.12b	<0.001
Initial LWT, kg	387.25±19.11	384.25±19.11	382.14±14.45	0.977
Final LWT, kg	389.25±19.46	392.27±19.46	387.65±14.71	0.982
Change in LWT, kg	2.00±1.39b	8.05±1.39a	5.51±1.05ab	0.035
ADG (g/day)	44.64±30.91b	178.37±30.91a	122.45±23.36ab	0.035
Initial BCS	3	3	3	0.877
Final BCS	3	3.25	3	0.692

Where, DMI=dry matter intake; CPI=crude protein intake; UMB= urea molasses block; .SE = standard error; ADG=average daily gain; LWT= live weight; BCS= body condition score; ns=non-significant; Different letters within a row indicate treatments are significantly different.

Table 5: Average daily milk yield (liter/day/cow) and milk composition

Parameter	Control	With UMB	Treated straw	*P*-value
Milk yield	8.71± 0.14^{c}	11.17±0.13^{a}	10.82±0.11^{b}	<.001
Fat, %	3.74±0.28^{b}	4.51±0.23^{a}	3.95±0.22^{b}	0.053
Protein, %	3.03±0.05	3.06±0.05	3.03±0.04	0.890
SNF, %	8.01±0.17	8.10±0.14	8.03±0.13	0.895
Total solid, %	11.81±0.29^{b}	12.68±0.24^{a}	11.97±0.23^{b}	0.058
Lactose, %	4.32±0.12	4.29±0.1	4.31±0.09	0.989
Density, g/ml	26.39±0.75	26.43±0.63	26.15±0.60	0.945

SNF=Solid not fat; UMB= urea molasses block; Value were adjusted using initial milk yield as covariate; Values with difference letters across a given row are statistically significant

Feed Intake, Live Weight Gain and Bcs of Experimental Cows: The daily DM and nutrient intake of experimental cows increased significantly (*P*<0.001) with the intervention diets (Table 4). Straw DM intake increased by 40.0% and 18.4% over the farmers' practice in the group fed UMB and urea-treated straw, respectively. Similarly, total DM intake increased significantly (*P*<0.001). Cows supplemented with UMB had significantly higher DM intake (*P*<0.001) than cows fed urea-treated straw. Previous studies have shown increased total DM intake of lactating crossbred cows fed on urea-treated straw [9, 10, 12] and urea molasses block supplementation [8]. The increase in feed intake with the new feeding regimes could be due to improved efficiency of rumen fermentation and feed digestibility.

Live weight change and ADG of lactating cows were increased significantly (*P*<0.05) with the intervention diets compared to farmers' practice. The cows supplemented with UMB showed the highest live weight change and ADG, but did not differ significantly (*P*>0.05) from cows fed on urea-treated straw. However, the BCS of lactating cows were not influenced (*P*>0.05) by feeding regimes.

Milk Yield and Composition: Cows fed on intervention diets had higher milk yield compared to cows of farmers' practice (Table 5). Average daily milk yield increased by 28.24% (2.46 liters/day) in UMB supplemented cows and by 24.22% (2.11litres/day) in cows fed urea-treated straw over the control. The daily milk yield of cows supplemented with UMB was superior to cows fed on urea-treated straw with extra yield of 0.35 liter/cow. The increase in milk yield with the intervention diets could be resulted from increased DM and nutrient intake. A higher milk yield increase (3.4 kg/day, or 95.08% increase) than the present was reported for crossbred dairy cows fed on urea-treated tef straw [10]. Moreover, a research report [21] have showed no variation in milk yield among cows fed on natural grass hay, urea-treated barely and tef straws, perhaps indicating a comparable nutritive quality of urea-treated straws and natural grass hay.

Economic Importance: Table (6) shows the cost of milk production and income from its selling. All variable costs (purchased items and feed preparation) were considered. The production cost increased with increase in the

Table 6: Economic importance of straw urea treatment and UMB to lactating dairy cows

	Control	With UMB	Urea-treated straw
Cost of feeds/cow			
Straw	489.03	560.60	512.99
Concentrate	1001.46	1170.90	1095.39
Poultry litter	168.94	-----	-----
UMB (+ production cost)	-----	102.60	-----
Straw treatment			
Cost of molasses	-----	-----	66.44
Cost of urea	-----	-----	162.24
Cost of polyethylene plastic	-----	-----	120
Cost of labor	-----	-----	60
Total variable cost/cow	1659.43	1834.109	2017.07
Change in variable cost		174.67	357.64
Gross profit from sale of milk	4577.75	5239.5	5047.51
Net profit/cow	2918.31	3405.39	3030.45
Net profit/over control	-----	487.07	112.13

UMB=urea molasses block; all costs in Ethiopian currency (the then 1USD=18.3ETB), urea (10.5/kg), molasses (2.15/kg), noug seed cake (5.05/kg); wheat bran (3.6/kg), cement (2/kg), salt(3/kg), poultry litter (2.84/kg), urea untreated straw (1.66/kg),molasses (2.15/kg), common salt (2/kg), polyethylene sheet (12 ETB /meter), cost of labor (20/man/day; 2 men x 2 days for UMB, and 3 men x 1 day for straw treatment), and the prevailing sale price of milk (10 ETB/liters).

variable cost in the intervention diets compared to farmers' practice. However, the net profit per farm increased by 16.69% in UMB supplemented group and by 3.84% in treated-straw fed group over the control due to increase in milk yield by 41.95% in the former and 17.40% in the later. This in turn increased the gross income from milk selling.

Farmers' Perception on the Feed Technologies: A workshop was conducted at the research center to discuss on the importance of the transferred technologies, constraints faced and way forward. In general, farmers' view on the technologies' acceptance, relevance and economic benefit was positive. They witnessed that both urea-treatment and UMB making can be adopted on-farm and useful, particularly during dry season when family labor is cheap and good quality feed is in scarce. However, farmers did not hesitate to report that adapting animals to UMB feeding took longer days than expected, and also re-using the same pit for straw urea treatment might be impractical as its walls disintegrate. In this regard, use of concrete pit, or plastic sacks was suggested as alternative. Also, farmers worried that the low availability of inputs (e.g molasses, urea, concentrates) and their unaffordable price would limit the sustainable use of the technologies. They discussed and agreed to purchase inputs in group (organized manner) than on individual basis. Also suggested, the local Dairy Cattle Producers Cooperative (*Ada* and *Jitu*) should take initiative in availing inputs for members at a reasonable price.

CONCLUSION

The study revealed that the dairy farms in and around Bishoftu town faced various production challenges, of which feed shortage and its rocketed price was a notable one. Crossbred dairy cows fed on urea-treated straw and UMB based diets had increased milk yield, milk fat content and the net benefit of production over the traditional feeding practice. Improving farmers' access to inputs at a reasonable price would promote dissemination and adoption of the technologies by many other farms.

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