On-Farm Evaluation of the Effect of Concentrate and Urea Treated Wheat Straw Supplementation on Milk Yield and Milk Composition of Local Cows

Adebabay Kebede[1†], Firew Tegegne [2], Zeleke Mekuriaw [3], and Azage Tegegne[4]

[1]Andassa Livestock Research Centre, P.O. Box 27, E-mail: adugsen@gmail.com;
[2]Bahir Dar University, P.O. Box. 26, E-mail: firewtegegne@yahoo.co.uk;
[3] Bahir Dar University, E-mail: zeleke_mekuriaw@yahoo.co.uk
[4]International Livestock Research Institute (ILRI), P.O.Box 5689, E-mail: a.tegegne@cgiar.org

[†]Corresponding author

Abstract

On-farm feeding trial was conducted with the objective of evaluating the effect of supplementation on milk yield & milk composition of local cows. Twenty lactating cows of uniform parity and stage of lactation were used. Average body weight and initial milk yield of cows were 231.7±36.7 kg & 1.08±0.11 kg/cow/day respectively. The treatment groups included grazing (control) (T_1), noug seed cake (T_2), ad lib urea treated wheat straw (T_3), noug seed cake + ad lib urea treated wheat straw (T_4) and concentrate comprising 74% maize grain+25% noug seed cake + 1% salt (T_5). Significant difference (P<0.05) between control and supplemented groups was observed in terms of increased milk yield, milk-fat and total solids while supplemented groups were not-significantly different (p>0.05), for increased milk protein, solids-not-fat and ash contents. The highest and the lowest milk yield per cow per day were recorded for cows fed urea treated wheat straw and the control group, respectively. The intervention diets increased the net profit/cow/day by ETB 3.40 (T_2), 6.33 (T_3), 3.58 (T_4), and 3.84(T_5) over the control (T_1). In general, urea treated wheat straw supplementation improved milk yield, and economic return. Hence, the government and other concerned bodies should pay due attention to scale up the feeding package developed considering the respective milk production systems to capitalize market oriented milk industry in the district and similar areas.

***Key words**:* Bure district, local cows, milk composition, milk yield, supplementation, urea treatment

1. Introduction

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

Bure is one of the districts of West Gojjam Administrative Zone in Amhara National Regional State (ANRS). It is one of the pilot learning sites of Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project and surplus agricultural products producer districts of ANRS (Yigzaw and Kahsay, 2007 -unpublished). It is believed to have high potential for milk development. In Bure district, the increasing pressure on land to grow food crops and the ever expanding human population has resulted in a reduction in grazing land. Crop residues from cereals such as teff straw, millet straw, barley straw and maize stover mainly form the basal diets of the animals. In other words, wheat straw was not efficiently used. However, crop residues are inherently believed to have low CP, digestibility and intake and deficient in minerals (Rihirahe, 2001).

In Bure district wheat straw is not efficiently used by livestock owners. The farmers do not collect and store it for feed of dry season; rather they used to burn it. Because of its course nature they regard it as the cause of coughing to their animals. However, various literatures confirmed that wheat straw's nutrient content can be improved through urea treatment. Thus, the objectives of this study were to evaluate the effect of urea treated wheat straw and concentrate supplementation on milk yield and milk composition of local cows and to evaluate the economic feasibility of urea treated wheat straw and concentrate supplementation.

2. Materials and methods

2.1. Location and description of the study area

The study was conducted at Wangedam Kebelle in Bure district of Amhara National Regional State from March 15 to April 28, 2009 excluding the adaptation period. Bure town, the capital of the district, is located 400 km north-west of Addis Ababa and 148 km south-west of Bahir Dar. The total area coverage of the district is 72,739 ha, of which 46.6% is cultivated. Agro-ecologically, it is classified into low-land (10%), mid-altitude (82%) and high- altitude (8%). The altitude drops from 2,604 to 713 meters above sea level as one travels from north to south part (Abbay Gorge) of the district. The minimum and maximum temperature of the area is 17^0C and 25^0C, respectively, while, the minimum and the maximum rainfall is 1386 mm and 1757 mm, respectively. About 76%, 17% and 5% of the total area is plain, rugged mountains and valleys, respectively. The crop types of the area include cereals, pulses, oil crops, vegetables, spices and other perennial crops, while the livestock species include cattle, small ruminants, equines, poultry and beehives. According to the Office of Agriculture and Rural Development (2006) report, 71,924 cattle, 8,294 goats, 15,225 sheep, 47,159 poultry, 6,684 equines, and 13,329 honeybee colonies are found in the district. Broadly, the mixed crop–livestock production system in the rural (suburb) areas and the urban (landless) milk cattle production system are dominant in Bure district (Adebabay, 2009). In Bure district 93% of the total cattle population was local zebu cows (Ibid).

2.2. Experimental design and treatments

A Randomized Complete Block Design (RCBD) was used to carry out the feeding trial. Initial body weight of the experimental cows was used as a basis for blocking. The experimental cows were randomly allotted to each of the five dietary treatments (Table 1).

Table 4: Experimental treatments

Treatments	Description	Supplementation level
T_1	Grazing (control)	-
T_2	Control + NC	0.25 kg/Kg of milk yield
T_3	Control + UTWS	*ad lib*
T_4	Control + NC + UTWS	0.25kg/kg of milk-0.2*0.25kg/kg of milk
T_5	Control+ Concentrate*	0.25 kg/Kg of milk yield

NC = Noug seed cake; UTWS = urea treated wheat straw; *74% maize grain + 24% NC + 1% salt.

Noug seed cake and concentrate supplementation was based on milk yield performance of experimental cows. About 0.25 kg was given per kg of milk yield per day (Holeta Research Centre, 2004 as cited in BOARD, 2005). When noug seed cake was supplemented with urea treated wheat straw, it was supplemented at a level of 0.25 kg per kg of milk - 20% * 0.25 kg per kg of milk.

Experimental feeds were selected based on their availability in the study area. Secondary data were used to formulate concentrate mixtures (Seyoum *et al*, 2007). Concentrate rations were formulated based on the nutrient requirement of lactating cows in the tropics, which is 75% TDN and 17% CP on the average and the fact that most of the Ethiopian dry forages and roughages have a CP content of less than 9% (mean 6.2%) (Yoseph *et al*, 2003). The concentrate ration was formulated to have 74% of maize grain, 24% of noug seed cake and 1% salt using Pearson square balancing method. One hundred kg of wheat straw was treated with 5 kg urea (46% N) and 100 litres of water and ensiled in a pit size of 2m*1m*1m for a period of 21 days.

2.3. Experimental animals and feeding management

A total of 20 lactating local cows of uniform parity and stage of lactation were selected purposively for the feeding trial. Cows were housed at night under farmers' traditional house. Average body weight of the selected cows was 231.7± /day ranging from 0.64 to 1.28 kg/cow/day. The cows were tested against mastitis using 36.7 kg ranging from 175 to 274 kg with an average initial milk yield of 1.08±0.11 kg/cow California Mastitis Test and dewormed for internal parasites with broad spectrum anthelmintic Zanisol (2400mg/150 Kg) prior to the start of the experiment. The treatment diets were given to the dairy cows individually for a period of 45 days and an adaptatdays. The initial and final body weights of the cows were estimated using heart-girth measurements. The experimental cows were allowed to graze for the whole day and recommended amount of supplements were given in two equal portions at 8:00 am and 8:00 pm each day. The experimental cows were provided with water *ad lib*. Samples of feeds offered from all feed supplements and refusals from only urea treated wheat straw weion period of 15 re collected, weighed and bulked and kept for chemical analysis. All the cows were hand milked twice a day (at 7:00 am and at 7:00 pm) and milk yield measurements were taken by using graduated bottles at the start of the experiment and during the entire study period.

2.4. Chemical analysis

Feeds offered and refusals from urea treated wheat straw samples were taken daily per cow, bulked on a weekly basis and oven dried at 65^{o} C for 72 hours. All samples of feed offered and refusals from urea treated wheat straw were analyzed for DM and N (Kjeldahl-N) according to AOAC (1990) procedures. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the methods of Van Soest and Robertson (1985). *In vitro* organic matter digestibility (IVOMD) of feeds offered and refused were determined using procedures outlined by Tilley and Terry (1963). Metabolizable energy (ME) value was estimated from the percent IVOMD: ME=0.16 (% IVOMD) (McDonald *et al*. 2002). Hemicellulose was calculated as the difference between %NDF and %ADF.

About 100 ml pooled milk samples from each morning and evening milkings were collected from each experimental cow fortnightly for a period of 45 days. The milk samples were kept in an ice box and delivered to Bahir Dar University Food Technology and Processing Engineering Department for analysis. Chemical composition of milk samples was determined following standard methods (Marth, 1978). Fat content of the milk was estimated using the Gerber analytical method (O'Connor, 1995). The formaldehyde titration method was used to determine the total protein content of milk (O'Connor, 1994). To determine the total solids content, oven drying method was used (Richardson, 1985). The solid-not fat content was determined by subtracting the percent fat from total solids. The total ash content was determined by igniting the dried milk samples in a muffle furnace (Richardson, 1985).

2.5. Partial budget analysis

The economic analysis was based on the calculation of the total cost of supplemented feeds and considering milk sales price and labour cost incurred during the entire experimentation period. The price of milk at Wangedam Kebelle was fixed to calculate the income obtained per milk yield per day. The costs of ensiling facilities had also been included in the analysis. Partial budget analysis was employed to compute total cost of production /cow/day, mean kg of milk/treatment/

day, cost of production/kg of milk, gross income from sale of milk/treatment/day, net profit/cow/day, and net profit/treatment/day.

2.6. Statistical analysis

Data from milk yield and milk composition, voluntary dry matter intake and IVOMD data were subjected to analysis of variance (ANOVA) procedure for RCBD (SAS, 1999). Means were separated using Duncan's Multiple Range test. The initial milk yield was used as covariate to adjust milk yields during the experimental period. The statistical model used was:

$Y_{ij}=\mu+a_i+b_j+e_{ij}$

Where,

Y_{ij}= the dependent variable (milk yield or composition)

μ= the overall mean

a_j= the effect of the i^{th} diet

b_j= the effect of the j^{th} block

e_{ij} = random variation

3. Results and discussion

3.1. Chemical composition and in-vitro organic matter digestibility of treatment feeds

The chemical composition and IVOMD of treatment feeds offered to experimental cows is presented in Table 2. Fibrous crop residues and natural pastures in the dry season are of low nutritive value and below the quality to meet the nutritional requirement of livestock (Mesfin *et al*., 2009). Particularly, untreated wheat straw is generally characterized by low CP (3.9%), ether extract (EE) (1.6%), IVOMD (38.0%), estimated ME (7.14 MJ/Kg), but high in neutral detergent fibre (NDF) (77.2%), acid detergent fibre (ADF) (48.2%) and lignin (7.9%) (EARO, 2004). The fibre content is higher than the value suggested limiting the feed intake of animals. The CP content was lower than the threshold required putting an animal in a negative nitrogen balance. Similar results were found for untreated wheat straw for CP, N, NDF, ADF, IVOMD and ME. The study also showed a considerable increment in nutrient content of wheat straw as a result of urea treatment. Ammoniating wheat straw with urea increased CP content (N*6.25) from 2.66 to 6.09% on DM basis (increased by 128.95%). In contrast, the NDF, ADF and hemicelulose content of treated wheat straw was less than untreated wheat straw. This might be due to the dissolving effect of urea treatment on NDF, ADF and hemicelulose fraction and subsequent removal from the cell wall constituents. Similar results were reported by Rehirahe (2001) and Getu (2009) in urea treated barley and teff straw in the highlands of Ethiopia and wheat straw at Holeta Agricultural Research Center, respectively. In general, the response of wheat straw to urea treatment was very promising and was found to be comparable to previous results reported by Sundstøl (1978) and Cottyn and DeBoever (1988).

Even though the amount of CP obtained as a result of urea treated straw supplementation is below the minimum requirement (6.2%) when added to the CP consumed from grazing it is supposed to satisfy the requirement of the individual experimental cows. The percentage improvement in CP content of wheat straw due to urea treatment in this study is higher than the finding of Mesfin *et al* (2009) for urea treated teff straw in North Shewa which showed an increment of 107% (4.3 to 8.9%). The difference in the degree of improvement might be attributed to the variations in the type of silo used (under ground versus above ground), urea treatment and ensiling process. Similarly, the estimated metabolizable energy of urea treated wheat straw (8.00 MJ/kg DM) was higher than the figure obtained from untreated wheat straw (5.50 MJ/kg DM). Besides, the IVOMD of wheat straw was improved by 54.5% when treated with urea.

Table 2: Chemical composition, in-vitro organic matter digestibility and estimated metabolizable energy of experimental feeds

Measurements	UTWS	TWS		NC	Concentrate
		Offer	Refusal		
DM (%)	96.1	95.7	93.4	95.2	92.3
		% of DM			
Ash (%)	5.8	9.4	9.4	6.3	2.8
OM (%)	94.2	90.6	90.6	93.7	97.2
CP (%)	2.7	6.1	5.4	32.2	16.6
NDF (%)	81.5	38.1	32.6	12.00	15.5
ADF (%)	55.5	12.4	23.4	9.8	8.7
Hemicelluloses* (%)	26.0	25.6	9.2	2.1	6.7
IVOMD (%)	34.2	52.8	49.7	69.2	81.3
EME, MJ/kg*	5.5	8.0	8.0	11.0	13.0

*EME = 0.16 (%IVOMD) as cited in McDonald *et al.* (2002); Hemicellulose = %NDF - %ADF; UTWS = untreated wheat straw; TWS = treated wheat straw; NC = Noug seed cake

3.2. Dry matter and nutrient intake

The dry matter intake (DMI) and nutrient intake of experimental cows are presented in**Error! Reference source not found.**3. The DM, NDF and ADF intake from supplemented feeds was significantly different (P<0.05) in the order of T3>T2>T4>T5 for the DMI and T3>T4>T2>T5 for NDF and ADF. The CP intake of experimental cows supplemented with noug seed cake and urea treated wheat straw was higher (309 g/day) followed by cows supplemented with sole noug seed cake (306.48 g/day). The metabolizable energy intake (ME) of experimental cows in T2 was the highest (10.47g/day) of all treatment groups.

Table 3. Dry matter and nutrient intake (g/day) from supplemented feeds by lactating local cows grazed on natural pasture*

Treatment	DM intake	Nutrient intake			
		CP	ME	NDF	ADF
T_2	951.80^b	306.48^b	10.47^a	333.03^c	58.44^c
T_3	956.60^a	58.26^d	8.03^c	746.63^a	180.70^a
T_4	904.93^c	309.81^a	10.06^b	397.00^b	77.46^b
T_5	461.40^d	76.55^c	6.00^d	117.47^d	54.08^d
Mean	818.6825	187.775	8.64	398.5325	92.67
CV (%)	11.4	7.2	5.0	8.7	11.8

*Means with different superscripts within a column are significantly different (P<0.05);
T_2 = Noug seed cake (NC); T_3 = *ad libitum* urea treated wheat straw; T_4 = urea treated wheat straw + NC; T_5 = concentrate; TDM = Total

dry matter; CP = Crude protein; ME = Metabolisable energy; NDF = Neutral detergent fibre; ADF = Acid detergent fibre

3.3. Milk yield and composition

Results of the effect of dietary supplements on average daily milk yield ($P<0.05$) and compositions are presented in Table 4. Supplemented cows produced significantly more milk ($P<0.05$) than those grazed on natural pasture alone. Similar results were also reported by Mesfin *et al.* (2009) and Getu (2008) who indicated that crossbred cows fed urea treated teff straw and wheat straw, respectively had significantly higher milk yield than for non-supplemented crossbred cows. The fat content of milk was significantly higher ($P<0.05$) for T_1 compared to T_3 and T_5. Treatment 3 had the lowest fat content of all the dietary treatments. This result is in contrast with the finding of Getu (2008) who found non-significant difference ($p>0.05$) for milk fat, milk protein, and total solids in urea treated wheat straw fed cows. However, treatment effects were not-significantly different ($p>0.05$) for milk protein, solid-not-fat and ash contents in this study. Dry matter intake was positively correlated with milk yield, protein, fat, and total solids contents of milk (Table 5). In contrast, it was negatively correlated with total solids and ash composition of milk from the respective treatments.

Table 4: Milk yield and milk composition from lactating local cows fed experimental feeds*

Treatment	Mean yield (kg/day)	Milk composition (%)				
		Fat	Protein	TS	SNF	Ash
T_1	0.45^{b}	5.02^{a}	2.78^{a}	12.63^{ab}	8.50^{a}	0.62^{a} 0.66^{a}
T_2	1.61^{a}	3.97^{ab}	2.96^{a}	14.35^{a}	14.01^{a}	0.46^{a}
T_3	2.18^{a}	2.80^{c}	3.05^{a}	11.11^{b}	8.65^{a}	0.59^{a}
T_4	1.51^{a}	4.07^{ab}	2.61^{a}	13.19^{a}	8.53^{a}	0.63^{a}
T_5	1.53^{a}	3.60^{bc}	2.67^{a}	12.64^{ab}	8.61^{a}	
Overall mean	1.46	3.89	2.81	12.79	9.66	0.59
SED	0.27	0.32	0.21	0.91	0.38	0.12
CV%	36.71	14.63	7.47	7.16	39.81	20.60
R^2	0.66	0.76	0.61	0.72	0.48	0.48

*Means in a column with different superscripts are significantly different ($P<0.05$)
T_1 = Control; T_2 = Noug seed cake (NC); T_3 = *ad libitum* urea treated wheat straw; T_4 = Urea treated wheat straw + NC; T_5 = Concentrate; SED = Standard error of difference; CV% = Coefficient of variation; TS=Total solids; SNF=Solid-Not-Fat.

Table 5: Correlations between DMI and milk yield and composition parameters

Variables	DMI*
Milk yield	0.4
Protein	0.6
Fat	-0.5
Total solids	0.1
Solid-not-fat	0.4
Ash	-0.4

*Correlations are not significant at 5 %

Lactation curve of cows fed on experimental feeds for period of 45 days is depicted in the Figure below. Even though concentrate fed cows were expected to perform better than those on other treatments, higher milk per day was recorded from urea treated wheat straw fed cows compared to other treatments followed by concentrate fed cows. This might be due to the higher DMI of cows supplemented with urea treated wheat straw. Cows in the control group ceased to give milk starting from week 5 (day 28). This showed that unless one supplements lactating cows in times of feed shortage, milk production will decline or completely dry off regardless of the stage of lactation.

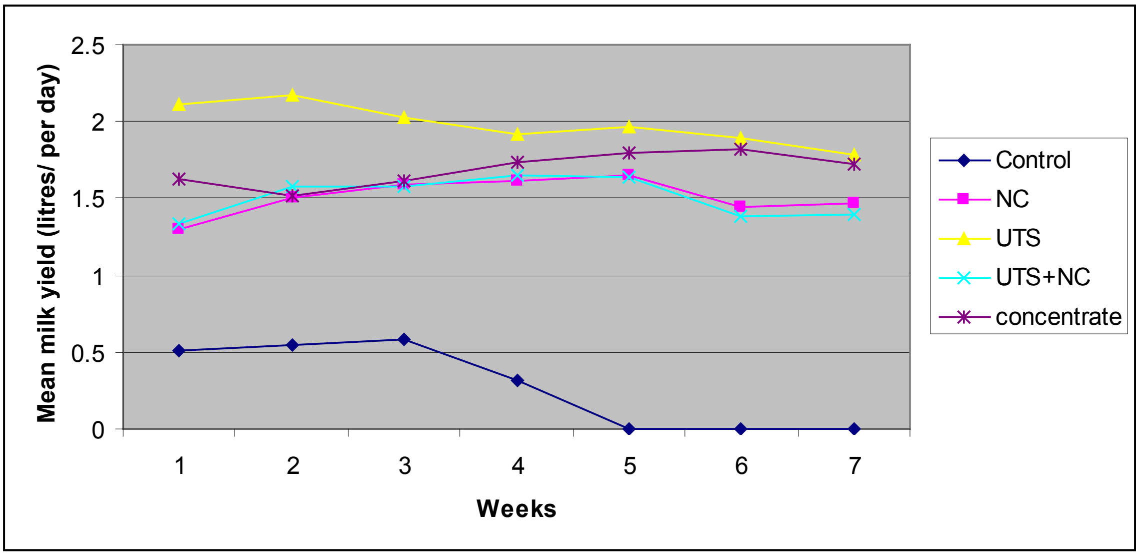

Figure 1: Lactation curve of cows fed on experimental diets

3.4. Economic evaluation of treatment feeds

The cost of grazing for the control group was not considered; while the total cost of production was considered since other variable costs (medicaments) were the same for the entire treatment groups. The gross profit from sale of milk per treatment per day increased from ETB 1.80/cow/day to ETB 6.44/cow/day in T_2; ETB 8.72 /cow/day in $T_{3;}$ ETB 6.04 /cow/day in $T_{4;}$ and ETB 6.12/cow/day in $T_{5.}$ The net profit increased from ETB 1.80/cow/day in T_1 to ETB 5.20/cow/day in $T_{2;}$ ETB 8.13/ cow/day in T_3; ETB 5.38 in T_4; and ETB 5.64 in $T_{5.}$ Hence, this study demonstrated that feeding the intervention diets to local milk cows increased the net profit for farmers to ETB 3.40/cow/day (T_2), ETB 6.33/cow/day (T_3), ETB 3.58 /cow/day (T_4), ETB 3.84/cow/day over the farmers' practice (Table 6). The highest economic benefit was gained from feeding urea treated wheat straw (T_3) which is really an advantage for small holder farmers who have better access to crop residue resources than concentrates. This might be due to the fact that higher milk yield per day was recorded in urea treated wheat straw supplementation than other feed treatments. In this regard, it is worth mentioning that the variable cost incurred during the ensiling process can even be minimized by using alternative ensiling facilities which are under farmers' holding. In contrast, the highest cost per cow per day and a relatively less milk yield was gained from supplementation of noug seed cake, which was accompanied by lowest economic return compared to other treatments.

Table 6: Economic evaluation of experimental feeds fed to lactating local cows

Costs and benefits	Feed treatments				
	T_1	T_2	T_3	T_4	T_5
Cost of straw treatment (ETB)			58.00		
Cost of noug seed cake (ETB)	-	90.00	-	45.00	-
Cost of Concentrate	-	-			33.05
Total variable cost (ETB)	0.00	360.0	232.00	180.00	132.20
Cost /cow/experimental period (ETB)	0.00	90.00	58.00	45.00	33.05
Cost/cow/day (ETB)	0.00	2.00	1.29	1.00	0.73
Mean kg of milk per treatment per day	0.45	1.61	2.18	1.51	1.53
Cost /cow/kg of milk (ETB)	0.00	1.24	0.59	0.66	0.48
Gross income from sale of milk/treatment/day (ETB)*	1.80	6.44	8.72	6.04	6.12

Net profit (ETB)	1.80	5.20	8.13	5.38	5.64
Net profit over the control/treatment/day (ETB)	-	3.40	6.33	3.58	3.84

*Price per litre of milk fixed at 4 ETB (Ethiopian Birr); T_1 = Control; T_2 = Noug seed cake (NC); T_3 = *ad libitum* urea treated wheat straw; T_4 = Urea treated wheat straw + NC; T_5 = Concentrate

4. Conclusions and recommendations

On-farm evaluation of treatment feeds showed a significant difference (P<0.05) between the treatment groups in terms of response in milk yield and composition of milk fat and total solids. Urea treated wheat straw supplementation improved milk yield and economic return. Besides, economic evaluation of treatment diets showed that the treatment diet to local milk cows increased the net profit for farmers up to ETB 6.33/cow/day (T_3) over the farmers' practice. Hence, the government and other concerned bodies should pay due attention to scale up the feeding package developed in this study considering the respective milk production systems to capitalize market oriented milk industry in the district and similar areas.

References

Adebabay Kebede, 2009. Characterization of Milk Production Systems, Marketing and On- Farm Evaluation of the Effect of Feed Supplementation on Milk Yield and Composition of local cows at Bure district. M.Sc. Thesis. Bahir Dar University, Ethiopia.

AOAC (Association of Analytical Chemists), 1990. Official Methods of Analysis. 15th Edition. AOAC Inc, Arlington, Virginia, USA.

BOARD (Bureau of Agriculture and Rural Development), 2005. Livestock Feeding Strategy Manual. Bahir Dar, Ethiopia (In Amharic).

BoFED (Bureau of Finance and Economic Development), 2006. Development Indicators of Amhara Region. 4th ed. Bahir Dar, Ethiopia.

Cottyn, B. J. and J. L. De Boever, 1988. Upgrading of Straw by Ammoniation. Animal Feed Science & Technolgy. 21: 38-48.

EARO (Ethiopian Agricultural Research Organization), 2004. Training on: Recent Development in Animal Feeds and Nutrition Organized for Agricultural Experts in West, South-West, and North-Shewa Zones. May 10-11, 2004, Holetta, Ethiopia. 40p.

Exxun, 2008. Economy Overview. http:/www.exxun.co /Ethiopia/e-ec.html. Retrieved on 22 Sept, 2008.

Getu Kitaw, 2008. Replacement of Formulated Concentrate mix with Vetch (*Vicia dasycarpa*) Hay to Lactating Crossbred Dairy Cows Fed on Urea Treated Wheat Straw. M.Sc. Thesis, Alemaya University, Ethiopia.

Marth, E.H. (ed.), 1978. Standard Methods for the Examinations of Milk Products. American Public Health Association, Washington, DC. 416p.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh, C. A. Morgan, 2002. Animal Nutrition (6th ed.). Pearson Educational Limited. Edinburgh, Great Britain. 544p.

Mesfin Dejene, Seyoum Bediye, Aemiro Kehaliw, Getu Kitaw and Kedir Nesha, 2009. On-farm Evaluation of Lactating Crossbred (*Bos Taurus* X *Bos Indicus*) Milk Cows Fed a Basal Diet of Urea Treated Teff (*Eragrostis Tef*) Straw Supplemented with Escape Protein Source during the Dry Season in Crop-Livestock Production System of North Shoa, Ethiopia. *Livestock Research for Rural Development. Volume 21, Article #61*. Retrieved April 5, 2009, from http://www.lrrd.org/lrrd21/5/deje21061.htm

O'Connor, C.B. 1995. Rural Milk Technology Training Manual. Addis Ababa, Ethiopia

O'Connor, C.B., 1994. Rural Dairy Technology. ILRI Training Manual No. 1. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. 133p.

Rehrahie Mesfin, 2001. Biological and Economical Evaluation of Feeding Urea Treated Teff and Barley Straw Based Diets to Crossbred Milk Cows in The Highlands of Ethiopia. M.Sc. Thesis. Swedish University of Agricultural science, Uppsala, Sweden.

Richardson, G. H., 1985. Standard Methods for the Examination Of Milk Products. 15th ed. American Public Health Association. Washington, D. C. pp. 168-196.

SAS (Statistical Analysis System), 1999. Statistical analysis system Institute, SAS/STAT user Guide, Version 8.1, SAS Institute Inc., Cary, NC, 1999.

Seyoum Bediye, Zinash Sileshi and Dereje Fekadu, 2007. Chemical Composition and Nutritive Values of Ethiopian Feeds, Research Report No. 73. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia, 33 pp.

Sundstøl, F., E. Coxworth and D. N. Mowat, 1978. Improving the Nutritive Value of Wheat Straw & other Low Quality Roughages by Treatment with Ammonia. World Animal Review, 26:13-21.

Tilley, J. M. A. and R. A. Terry, 1963. A Two-Stage Technique for *In Vitro* Digestion of Forage Crops. Journal of the British Grassland Society, 18:104.

Van Soest, P. J.and J. B. Robertson, 1985. Analysis of Forage and Fibrous Foods. A Laboratory Manual for Animal Science. Cornell University, Ithaca, New York, USA.

Yigzaw Desalegne and Kahsay Berhe. 2007. Bure Pilot Learning District Diagnosis and Program Design (Unpublished).

Yoseph Mekasha, Azage Tegegne, Alemu Yami, and N. N. Ummuna, 2003. Variations in Nutrient Intake of Milk Cows and Feed Balance in Urban and Peri-Urban Systems in Ethiopia. pp. 177-184. In: Proceedings of 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP). August 22-24, 2002, Addis Ababa, Ethiopia.