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Livestock feed resources, nutritional value and their implication on animal productivity in mixed farming system in Gasera and Ginnir Districts, Bale Zone, Ethiopia

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The study was conducted in Gasera and Ginnir districts of Bale mid to highland areas, Oromia regional state, southeast Ethiopia; to assess livestock feed resources, to determine major feed nutritional value and their implication on animal productivity. Stratified random sampling (poor, medium and wealth) was applied to identify the sampled unit of 156 households in the selected districts. The chemical compositions of sampled feeds were determined using wet chemistry at Holeta Agricultural nutrition laboratory. Livestock production systems in the districts were extensive type. The metabolizable energy (ME) of the major available roughage feeds was 956,094.71 and 980,392.51 MJ per annum in the Gasera and Ginnir districts, respectively. Crop residues (aftermath and barley straw, wheat straw and teff straw) contributed about 80.4 and 81.73% in Gasera and Ginnir, respectively of the total annual ME supply of roughage feeds where the remaining is from natural grasses. The DCP (digestible crude protein) amount estimated in sampled feed was not statistically different in the study districts ($P > 0.05$). Crude protein (CP) and in vitro dry matter digestibility (IVDMD) were significantly higher ($P < 0.05$) for feed from natural grasses than crop residues and aftermath. To the contrary, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were significantly higher ($P < 0.05$) for crop residues and aftermath. Mean crude protein content of crop residues and aftermath was less than the critical level of CP (7% DM) required for optimum function of rumen microbes, implying the need for supplementation. On the other hand, the amount of dry matter available from major sampled feed sources indicated that, it satisfied the maintenance requirement of cattle; however, the bulkiness of the feed cannot indicate the quality of the utilizable nutrients. This implies supplementation with concentrates and improved forage feeds are compulsory to overcome energy and protein deficiency in both study districts, especially during dry periods for reasonable livestock production.

Key words: Livestock, feed resources, chemical composition.

INTRODUCTION

Ethiopia believed to have the largest livestock population in Africa. According to the recent CSA's (2012/13) sample survey report, Ethiopia is endowed with 53.99,

25.5, 24.06, 9.01, 0.92 and 50.38 million heads of cattle, sheep, goat, equines, camels and poultry, respectively, excluding non-sedentary populations of three zones of

Afar and six zones of Somali Regions. This indicates that, Ethiopia holds large potential for livestock products (milk, meat, manure, skin and hide) production in particular from large and small ruminants mainly due to its large livestock population, the relatively favorable climate and disease free environment (Holloway et al., 2000) compared to other tropical countries. In addition, the country enjoys diverse topographic and climatic conditions and hence livestock production at different levels takes place across all agro-ecological zones.

Because of the low potential for crop production, including absence of or limited irrigation technologies in Ethiopia and most countries in COMESA (Common Market for Eastern and Southern Africa), livestock remains a major source of income and food for the majority of rural people in mixed and pastoral farming systems. In this respect, livestock ownership, in terms of both quantity and quality is an important asset because of its multiple social, economic and cultural uses (UNESCO, 2012). Like other developing countries, agriculture is the largest economic sector in Ethiopia accounting for about 46% of the national GDP, employment of 85% of the labor force and 90% of the poor depend on the sector for their livelihood (World Bank, 2008). According to MoARD (2007), the livestock sector in Ethiopia accounts for 16% (national), 27-30% (agricultural) GDP, respectively and 13% of the country's export earnings. Similarly, World Bank (2011) reported that the livestock subsector provides 16% of the total GDP and generates 14% of the country's foreign exchange.

Different authors have classified livestock production systems in Ethiopia based on the criteria that include degree of integration of livestock with crop production, level of input and intensity of production and agro-ecology. Accordingly, about five production systems have been defined; namely mixed crop-livestock farming, pastoral, agro-pastoral, intensive dairying and peri-urban dairying (MoA, 1998; Mohammed et al., 2004; Yitay, 2007). Across these different production systems, the product from livestock basically (milk, draught power, meat, manure and cultural value) have vital place where the livelihood of small holder is based on integrated agriculture.

The mixed-farming system provides 50% of the meat and 90% of the milk production from the world and employs 70% of the world's poor livestock producers (Thornton and Herrero, 2001). Highland livestock production in Ethiopia supports 85% of the total human population (Deressa et al., 2008; World Bank, 2011). The importances of livestock production in Ethiopia, in particular in the study area (Bale Zone) were used as source of milk production, meat production, draught

power and cash income. In mid to high land area of Bale Zone, there are large number of livestock population. However, productivity of the sector is still poor because of lack of feed in quality and quantity among other factors, especially during dry season. Thus, this study was conducted in Bale mid to highland area to know available feed resources for livestock and finally to analyze the nutritional value of the feeds. At the end, this study was give baseline information for policy makers and farming community to take overcome problems regarding to livestock feed. Finally, this paper aimed to address the following specific objectives;

- i) To identify major livestock feed resources in the study area
- ii) To evaluate major livestock feed nutritional value in the study area and;
- iii) To assess the implication of feed resources and feeding strategies on livestock productivity under the existing farming system in the selected districts.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Bale Zone, Oromiya Regional State of Ethiopia. The Zone holds a total area of 63555 km² of landmass having 3 town districts and 18 rural districts of which 9 falls under the mixed farming system and the rest 9 are pastoral (BoFED, 2012).

Gasera district is found 490 km south east of Addis Ababa in the highlands of Bale Zone. Pelvic vertisols and Eutric nitosols soil types are dominant and they have good agricultural potentials (Bale Zone Agriculture Office). The main economic stay of the district is crop-livestock farming system. Major crops cultivated in the districts are wheat, barley, teff, maize, faba bean and linseed. On the other hand, livestock species raised by the farmers include cattle, sheep, goat, donkey, horse, mule and poultry with a population of 115,848, 13,119, 17,284, 17,318, 5,756, 1,237 and 36,560, respectively (CSA, 2012).

Ginnir district on the other hand is located at 570 km southeast of Addis Ababa in the mid and highlands of Bale Zone. The soil type is Chromic and Pelvic Vertisols which are very fertile with fairly good Agricultural potential (Bale Zone Agriculture Office). Cattle has the biggest population among the livestock species with 190,023 heads followed by goat, sheep and donkey (CSA, 2012).

METHODOLOGY

Sampling procedures and sample size

A reconnaissance survey was conducted and discussions held with with agricultural office of Bale zone as per the thematic research topics by Maddawalabu University to select the two mixed farming system districts for the study. From the mixed-farming system districts, two districts were selected based on the

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information of Zone Agriculture Office and thematic research need assessment of Maddawalabu University on existing problems related to crop-livestock farming, feed resources and other recurring issues. Based on the information obtained from the respective district offices of agriculture, with no consideration of the lowland *kebeles* in each district, six focal *kebeles* proportionally three from each district was randomly selected for household interview and feed sample collection.

The sample size of households were determined using Arsham (2005): $N=0.25/(SE)^2$, where: N = sample size, and SE = standard error of the proportion. Assuming the standard error of 4% at a precision level of 5% and the confidence interval of 95%, 156 households practicing crop-livestock farming were selected using random sampling technique for interview. The number of households per *kebeles* was fixed based on the proportion of the households practicing crop-livestock farming.

Before start the survey, semi structured questionnaire was pre tested on sample households to evaluate appropriateness of the design, clarity and interpretation of the question by farmers, relevance of the questions, quality of the data received and time taken for an interview to make appropriate modification and corrections. The prepared questionnaire was translated in to local languages (Afan Oromo) and administered to the interviewee's by co-investigator and enumerators. One-day training was organized for enumerators on how to administer the questionnaire. Interview was done by the co-researcher together with the enumerators and development agents from the target *Kebeles*. The interview were carried out at the farmer's home to enable counter checking of the farmer's response with respect to the livestock population and species, availability of feed resources, livestock feeding system. Group discussion was organized in each *Kebeles* with eight to ten key informants and development agents including farmers who had many years' experience and knowledge of mixed farming to collect data about livestock system and problems were ranked by vote.

The feed samples for laboratory analysis were consider the major livestock feeds of the following different feeds used by the farmers to feed their animals in the districts namely; mixed natural grasses, mixed fallow land herbaceous forages (grasses), wheat straw, barley straw, emmer wheat straw, teff straw, pulse hallums (straw), wheat bran and homemade concentrates.

Data collection

A combination of primary and secondary data was used. For primary data generation; field visits, interviews, focal group discussions, feed sampling and laboratory analysis were the methods employed; and for secondary data the sources were published or unpublished reports from different organizations and literatures.

Sample collection

Major livestock feed samples (mixed natural grasses, mixed fallow land herbaceous forages (grasses), crop residues and concentrates) were collected for laboratory analysis based on farmers' response during interview.

Estimation of forage biomass yield

To determine the potential forage biomass yield and DM, representative samples of mixed natural grass and herbaceous vegetation were taken from protected areas in wet season based on pasture plants full growth to 50% flowering stage. For grazing pasture (1 m x 1 m) area, harvesting was done at the ground level (Zewdie, 2010). Fresh weights of harvested samples were taken immediately by using a spring balance of 20g precision. For further

chemical analysis, a composite sample was taken from the bulk.

Dry roughage feeds (crop residue) samples were collected during dry season after crop was harvested and threshed. The quantity of available crop residues produced by farmers was estimated by applying grain to straw ratio as suggested by FAO (1987). Accordingly, for a ton of wheat, barley, emmer wheat and teff straw, a multiplier of 1.5 were used and for pulses haulm (straw) a multiplier of 1.2 were used. The quantity of potentially available crop residues for animal consumption were estimated by assuming 10% wastage (Adugna and Said, 1994) and the grazing potential of crop aftermath (stubbles) were estimated using a mean of 0.5 ton per ha (FAO, 1987). The amounts of grain yield obtained from the respective crops were quantified by interviewing the farmers and crosschecking it with the data recorded by development workers for any deviation.

Assessment of livestock feed requirement

The annual availability of feed was compared with the annual requirements of the livestock population. Livestock populations were converted in to Tropical Livestock Unit (TLU) according to Gryseels (1988). The DM requirements for maintenance was calculated based on daily DM requirements of 250 kg tropical cattle (an equivalent of 1 TLU). Nutrients supplied by each feed types were estimated from the total DM output and nutrient content of that feed on DM basis. The total nutrient requirements (DM, CP and ME) per day per TLU were estimated based on recommendations of Kearl (1982) and McCarthy (1986) for tropical livestock.

Chemical analysis of sample feeds

Chemical analyses of feed samples were performed at Holeta Agricultural Research Center's nutrition laboratory. The representative samples of major feed resources from the study districts were collected, bulked, dried, sub-sampled and ground to pass through 1 mm mesh sieve for determination of dry matter (DM), ash, nitrogen (N), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and *in vitro* dry matter digestibility (IVDMD). The samples were pre-dried at 135°C for two hours in an oven dry to remove the moisture content in the feed before chemical analysis and analyzed for DM, OM, CP and ash contents following the methods described by AOAC (1990). *In vitro* dry matter digestibility IVDMD, NDF, ADF and ADL were determined according to the methods of Van Soest and Robertson (1985). The crude protein (CP) content was calculated as $N \times 6.25$. Metabolisable Energy (ME) and Digestible Crude Protein (DCP) content of a particular feed were estimated from IVDOMD and CP contents, respectively based on the following equations.

- i) $ME (MJ/kg DM) = 0.15 \times IVDOMD (g/kg)$ (MAFF, 1984)
- ii) $DCP (g) = 0.929 \times CP (g) - 3.48$ (Church and Pond, 1982)

Statistical Analysis

Collected data was analyzed using appropriate software (SPSS, version 20). Descriptive statistics were employed to describe the various variables in the mixed crop-livestock production system.

RESULT AND DISCUSSION

Feed resources and feeding strategies

Available feed resources

The principal feed resources available to livestock in the

Table 1. Available annual major livestock feed resources in Gasera and Ginnir districts of Bale mid to highland areas.

Feed type	Gasera		Ginnir		Overall	
	DM (tons)	% (N=78)	DM (tons)	% (N=78)	DM (tons)	% (N=78)
Natural grass	4.86±0.35 ^a	36.76	3.53±0.47 ^b	34.64	3.96±0.41	35.70
Fallow land grass	0.89±0.02 ^a	12.29	0.68±0.03 ^b	13.60	0.74±0.03	12.34
Crop residue	8.35±0.78 ^b	31.19	9.14±0.86 ^a	33.06	8.77±0.82	33.12
Aftermath grazing	2.74±0.26 ^a	17.70	2.78±0.22 ^a	17.08	2.75±0.24	17.22
HMC	0.18±0.01 ^a	02.06	0.13±0.02 ^b	01.62	0.15±0.02	01.72
Total feed supply	16.02±0.28 ^a	100	16.26±0.32 ^a	100	16.37±0.30	100

^{ab} = means with different superscripts within a row are significantly different ($P < 0.05$); HMC= the mixture of partially milled cereal crops (barley, wheat, emmer wheat etc.) and pulse crops which are not used for human consumption. DM = dry matter; N = number of respondents.

Table 2. Estimated available major crop residues per household in Gasera and Ginnir districts of Bale mid to highland areas.

Crop residues	Gasera		Ginnir		Overall	
	Mean ± SE DM (tons)	%	Mean ± SE DM (tons)	%	Mean ± SE DM (tons)	%
Wheat	7.47 ±0.84 ^b	39.10	8.31 ± 0.53 ^a	42.08	7.76 ±0.42	40.59
Barley	2.07 ±0.33 ^a	32.34	1.79 ± 0.41 ^b	28.26	1.82 ±0.08	30.82
Emmer wheat	0.73 ±0.06 ^b	9.44	0.78 ± 0.10 ^a	9.12	0.76 ±0.01	09.28
Teff	0.54 ±0.04 ^b	8.56	0.76 ± 0.08 ^a	9.42	0.60 ±0.40	08.72
Pulses	0.28 ±0.02 ^a	5.76	0.29 ± 0.05 ^a	7.26	0.29 ±0.01	06.31
Maize	0.19 ±0.06 ^a	5.40	0.14 ± 0.06 ^b	3.76	0.16 ±0.07	04.28
Total residue supply	11.29 ±0.35 ^b	100	12.08 ±0.23 ^a	100	11.45±0.99	100

ab = means with different superscripts within a row are significantly different ($P < 0.05$); DM = dry matter; N = number of respondents; SE = standard error.

study districts included natural grass from (communal grazing land, individual pasture land and fallow land, road side, cultivated land borders (alley) and marginal lands), crop residues, crop aftermath and homemade concentrates (HMC) and it is coincided with the report of Alemayehu and Sissay (2003) and Yeshitila (2007). Generally, crop residues from (barley, wheat, emmer wheat, teff, pulses and maize) were found to contribute more to the feed resource base in the study area (Table 2) which reconcile with the report of Tolera. et al., 2012. The extent of availability of different type of feed resources like natural grass, fallow land grass varied significantly ($P < 0.05$) between the districts (Tables 1) even though aftermath grazing and total feed supply is not significantly different. Thus, the reason for the difference could be attributed to the variation in land-use system in the districts, frost, crop rust, crop diseases and whereby yield of crop residue is related to area of land allocated for crop production and the crop grain yield.

Table 2 indicates that from the feed supplied by crop residues; 40.49% was barley straw, 30.82% wheat and the other 28.69% (almost one third of the total residue) were supplied by teff, emmer wheat, pulses and maize stover in the study districts. Even though higher yield of wheat straw is associated with the allocation of more land to wheat cultivation, primarily due to availability of

improved seeds, productivity and encouraging price for this crop, its palatability as animal feed is very low. Pulses (field pea and faba bean) straws contributed only about 7.26% of the total crop residue while maize contributed 3.76%. This could be due to the low yield and small area of land allocated for the crops in the districts because of environmental and other related factors. The contribution of crop residues to the feed resource base in Ginnir was significantly higher ($P < 0.05$) than that in Gasera district (Table 2). Crop residues supplied about 61.29% of the annual DM available per household in Ginnir area (Table 8).

In Gasera district, pastureland including grazing of communal, individual and fallow lands provided 5.75 tons of the annual DM supply per household, which was significantly higher ($P < 0.05$) than that of Ginnir (4.21 tons) (Table 1). This indicates that livestock in Gasera district were relatively less dependent on crop residue for feed, whereby the rest of the feed was obtained from crop residues, crop aftermath and HMCs. Feed obtained from fallow lands was also significantly higher ($P < 0.05$) in Gasera (Table 1). This may be due to fallowing of the land, which is a common practice in the district. Feed from aftermath grazing was not significantly different ($P < 0.05$) in both districts. This might be associated with the land use system in the districts where more land is

Table 3. Feeding priorities of crop residues and supplements for livestock practiced in Gasera and Ginnir districts of Bale mid to highland areas (in % of respondents).

Animal type	Districts	Crop residue (rank)					Supplement feed (rank)				
		N	1 st	2 nd	3 rd	4 th	N	1 st	2 nd	3 rd	4 th
Oxen	Gasera	78	64.5	25.4	7.0	3.1	56	42.0	41.1	14.8	1.1
	Ginnir	78	66.2	25.0	8.8	---	53	38.1	45.7	14.1	2.1
	Overall	156	65.3	25.2	7.9	3.1	109	40.0	43.4	14.4	1.5
Lactating cows	Gasera	78	32.3	48.0	16.5	2.2	61	29.5	33.5	20.0	17.0
	Ginnir	78	30.0	52.0	14.7	2.3	65	32.0	28.4	24.0	15.6
	Overall	156	31.1	50.0	15.5	2.2	126	30.5	30.5	22.0	16.3
Calves	Gasera	67	11.4	23.5	48.0	17.1	70	45.0	40.0	15.0	---
	Ginnir	71	12.0	27.6	44.4	16.0	66	48.5	39.0	12.5	---
	Overall	138	11.5	25.1	46.2	16.5	136	46.5	39.5	13.5	---
Weak animals	Gasera	73	10.6	47.0	33.5	8.9	72	20.8	52.1	22.3	4.7
	Ginnir	70	6.0	40.6	47.4	6.0	72	34.7	24.2	31.1	10.0
	Overall	143	8.3	43.5	40.5	7.5	144	27.5	38.1	26.5	7.3

assigned to cultivation and crop grain yield that resulted in higher aftermath grazing potential.

The overall, feed DM did not significantly different ($P > 0.05$) for both Ginnir and Gasera districts (Table 1) which disagreement with the finding of Dawit et al. (2013). This is because of the available feed from crop residues in one district being compensated by that from pasture land in the other district. According to Sere and Steinfeld (1996), if more than 10% of the feed DM for livestock comes from crop subsector, the production system is categorized as mixed crop-livestock farming systems. Therefore, the production system in the districts is with the mentioned range which indicated that the system is classified as mixed crop-livestock production system.

Feeding strategy and seasonal feed supply

Feeding strategy depends on the nature of the farming system, objective of herding animals and the availability of feed resources in that area which is to be affordable by the farmers. Livestock of mixed type (cattle of different category, small ruminants and equines), except draft animals, were herded together on degraded communal pasturelands, roadsides and marginal lands. Draft animals and in some cases, lactating cows owned by different households in the locality were kept around crop lands herded or tethered (FGD and field observation). In line with this, farmers were ranked feeding priority of crop residues and supplements to the livestock types they owned (Table 3). About 66.2 and 64.5% of them gave priority to draught animals in feeding of crop residues in (due to disease, stress, feed shortage, etc) and calves were given comparable attention in feeding crop residue relative to oxen and lactating cows (Table 3). The reason for such type of management is probably to maintain

body condition of draught animals, particularly during peak times of cropland ploughing.

Feeding calendar

Grazing was the major source of livestock feed throughout the year on available poor grazing lands, in the districts with significant contribution of other feed resources during the dry season listed in Table 4.

Crop residues were the main source of feed during the dry season from early February to June when pasture from grazing area not able to provide reasonable quantity of feed in the study districts. Teff and emmer wheat residues were equally preferred next to barley straw while pulses and wheat straw are the last choice when the other residues are not available at enough quantity. Therefore, residues from cereal crops were collected and stacked under shade around homestead commonly after threshing the crop in dry season. Farmers usually fed pulse straw directly on threshing field rather than after storage. This may be due to the small quantity of pulse crop production and the straw from these crops is sensitive to moisture to develop moulds whereas straws from pulse crops are less palatable, said the respondents. In general, the intensity of cultivation and crop production is generally higher in both districts.

Livestock were allowed to graze aftermath of crops preferably that of barley twice in a year in both study districts as barley crop is planted twice a year. Aftermath grazing of cereal crops occurred after harvest from mid July to late August during short rainy season (mostly of barley and teff) and from November to April in Gasera and Ginnir districts. Initially, aftermath grazing is reserved and grazed privately for some period and then after

Table 4. Available feed resources and feeding calendar in the study districts.

S/N	Feed source	Months of the year												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	Natural grass	[Dark Green]					[Light Green]							
2	Fallow land grass	[Dark Green]				[Light Green]	[Dark Green]							
3	Aftermath	[Dark Green]			[Light Green]	[Dark Green]						[Light Green]	[Dark Green]	
4	Crop residue	[Light Green]	[Dark Green]	[Dark Green]	[Dark Green]	[Dark Green]	[Dark Green]	[Light Green]	[Light Green]	[Light Green]	[Dark Green]			
5	Supplement	[Light Green]	[Light Green]	[Dark Green]	[Dark Green]	[Dark Green]	[Light Green]	[Light Green]	[Light Green]	[Dark Green]				
Critical feed shortage		[Orange]					[Dark Green]							

= available and high utilization;
 = less available and low utilization;
 = either not available or preferred by animals;
 = critical time of feed shortage.

Table 5. Mean chemical composition and *in vitro* dry matter digestibility of major livestock feed resources in Gasera district of Bale mid to highland area.

Variables	DM	% of DM					
		Ash	CP	IVDMD	NDF	ADF	ADL
Natural grass	38.53 ^b	10.99 ^a	8.96 ^b	64.87 ^b	73.15 ^b	43.53 ^b	7.29 ^b ^c
Fallow land grass	25.06 ^b	8.96 ^b	10.21 ^b	69.55 ^b	71.56 ^b	42.61 ^b	5.65 ^c
Crop aftermath	94.62 ^a	9.12 ^{ab}	3.77 ^c	40.36 ^c	79.85 ^a	56.34 ^a	11.24 ^a
Wheat straw	93.55 ^a	9.14 ^{ab}	3.22 ^c	41.92 ^c	77.72 ^a	49.51 ^a	10.30 ^{ab}
Barley straw	92.89 ^a	9.67 ^{ab}	4.01 ^c	48.31 ^{bc}	75.26 ^a	48.45 ^a	8.97 ^b
Emmer wheat straw	93.52 ^a	9.72 ^{ab}	3.91 ^c	47.77 ^{bc}	76.72 ^a	49.82 ^a	9.01 ^b
Teff straw	93.13 ^a	9.01 ^{ab}	3.78 ^c	46.84 ^{bc}	74.17 ^{ab}	49.63 ^a	9.22 ^b
Pulses straw	93.64 ^a	8.91 ^b	7.33 ^b	54.44 ^c	66.23 ^{bc}	51.71 ^a	13.64 ^a
HMCs	88.12 ^a	6.52 ^c	16.13 ^a	86.05 ^a	40.55 ^c	28.47 ^c	5.11 ^c
Wheat bran	89.70 ^a	6.86 ^c	14.43 ^a	84.32 ^a	46.80 ^c	33.24 ^c	6.26 ^c

ab = means with different superscripts within a column are significantly different ($P < 0.05$); HMC= the mixture of partially milled cereal crops (barley, wheat, emmer wheat etc.) and pulse crops which are not used for human consumption DM = dry matter; CP = crude protein; DCP = digestible crude protein; IVDMD = *in vitro* dry matter digestibility; ME = metabolizable energy; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent fiber.

it became accessible to the community in the locality. This is probably to exploit the potential of crop aftermath at individual level since land available for stubble grazing is of private resource. Moreover, livestock have to be herded closely to protect from crop damage until harvesting of food crops is over in dry season. Homemade concentrates were provided for the animals in dry season when feed shortage is more pronounced and to some animals any time under special cases (FGD).

Chemical composition of major feed resources

Dry matter and ash content

The DM content of the natural grass from grazing and fallow land is significantly lower ($P < 0.05$) than crop residues and concentrates in the study districts (Table 5). Ash content of natural pasture from grazing land and fallow land was 10.99 and 8.96% in Gasera while 9.89

and 9.14% in Ginnir district, respectively. Similarly, ash content of homemade concentrate and wheat bran were found to be 6.52 and 6.86% of the DM in Gasera district. Ash content of the concentrates was significantly different ($P < 0.05$). This is due to the feed type (cereal grain products and by-products) difference and the actual dominating organic components in the feed. Higher ash content observed in the study area for natural pasture indicates that it may satisfy mineral requirement of the animals for production at the time of availability of that particular forage.

Ash content was found to be 9.12, 9.14, 9.67, 9.72, 9.01 and 8.91% of the DM for Aftermath, wheat, barley, emmer wheat, teff and pulses residues, respectively in Gasera district (Table 5). Similarly, the ash content of Aftermath, wheat, barley, emmer wheat, teff and pulses residues was found to be 10.22, 9.34, 9.11, 9.31, 9.31 and 8.95% of the DM, respectively in Ginnir district (Table 6). The values for wheat straw and crop aftermath are more comparable than others. Overall the ash content of

Table 6. Mean chemical composition and *in vitro* dry matter digestibility of major livestock feed resources in Ginnir district of Bale mid to highland area.

Variables	DM	% of DM					
		Ash	CP	IVDMD	NDF	ADF	ADL
Grazing land grass	44.97 ^b	9.89 ^a	8.10 ^b	63.96 ^b	74.537 ^b	45.62 ^b	7.82 ^c
Fallow land grass	35.17 ^b	9.14 ^{ab}	9.62 ^b	69.84 ^b	71.88 ^b	43.55 ^b	6.31 ^c
Crop aftermath	94.71 ^a	10.22 ^a	3.44 ^c	40.78 ^d	78.65 ^a	55.77 ^a	11.77 ^a
Wheat straw	93.72 ^a	9.34 ^{ab}	3.62 ^c	42.22 ^d	78.25 ^a	52.34 ^a	11.00 ^a
Barley straw	92.53 ^a	9.11 ^{ab}	3.92 ^c	49.83 ^{bc}	74.78 ^a	47.17 ^{ab}	8.80 ^b
Emmer wheat straw	93.14 ^a	9.31 ^{ab}	3.88 ^c	48.15 ^{bc}	76.86 ^a	48.03 ^{ab}	8.93 ^b
Teff straw	93.13 ^a	9.31 ^{ab}	3.78 ^c	49.28 ^{bc}	73.01 ^{ab}	49.14 ^{ab}	9.20 ^b
Pulses straw	93.57 ^a	8.95 ^b	7.02 ^b	51.60 ^c	69.75 ^{bc}	50.59 ^a	12.72 ^a
HMCs	87.87 ^a	6.54 ^c	16.44 ^a	86.66 ^a	38.85 ^c	30.32 ^c	5.42 ^c

ab = means with different superscripts within a column are significantly different ($P < 0.05$); HMC= the mixture of partially milled cereal crops (barley, wheat, emmer wheat etc.) and pulse crops which are not used for human consumption DM = dry matter; CP = crude protein; DCP = digestible crude protein; IVDMD = *in vitro* dry matter digestibility; ME = metabolizable energy; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent fiber.

crop residues in the study districts is comparable to the results of Solomon (2004) and Yitaye (1999) in different parts of Ethiopian highlands. In contrast, the latter author obtained ash content of 14.61 % DM for barley which much more than the current result. This variation may be due to environmental factors, crop management practices and varietal difference of the crops under production. According to Preston and Leng (1984), mineral content of straw is generally low and imbalanced but this may be quite adequate for maintenance, while the requirements for minerals by the animal for production are increased many fold. Therefore, mineral content of straw in the study area is likely to be insufficient for livestock production.

Crude protein content

Feed obtained from natural grass (grazing land and fallow land) at Gasera had relatively higher CP content than that from Ginnir (Tables 5 and 6). The lowest CP content of grazing land grass was 8.96% DM in Gasera and 8.10% DM in Ginnir district. The value is in agreement with the reports of Yihalem (2004) for northern highlands of Ethiopia. High CP content observed in the present study district may be attributed to high legume proportion of natural pasture at the time of harvest. In general, feeds harvested from natural grass, can support maintenance requirement of ruminants since CP content is above 7.2% DM (ARC, 1980).

Mean CP content of crop aftermath, wheat, barley, emmer wheat, teff and pulses straw was 3.77, 3.22, 4.01, 3.91, 3.78 and 7.33% DM in Gasera district, respectively. On the other hand 3.44, 3.62, 3.92, 3.88, 3.78, and 7.02% DM values found to be the CP content of aftermath, wheat, barley, emmer wheat, teff and pulses straw in Ginnir district, respectively (Tables 5 and 6). Lower CP content in Ginnir area may be related to the

longer period of time required for physiological maturity to harvest the crop which induces dilution of CP and enhances lignifications (McDonald et al., 1995). The mean CP content of pulses straw was found to be significantly higher ($P < 0.05$) than that of different crop straws (Tables 5 and 6). This is due to the high nitrogen content of the pulse crops as they are legumes. For wheat straw, however, CP content was found to be higher than the previous reports of 2.4% DM (Seyoum et al., 2001) and 2.7% DM (Gashaw, 1992) in the central highlands of Ethiopia. This may be due to varietal differences and variation in management practices as well as soil fertility gradient of the areas. For pulses straw mean CP content was 7.33 and 7.02% DM in Gasera and Ginnir districts, respectively (Tables 5 and 6).

All straws from different crops, except that of pulses had CP content of less than the critical level of CP for optimum microbial rumen function (Van Soest, 1982). However, it was mentioned in the previous section that out of available feed resources in the study area, crop residues and crop aftermath contributed significant amount of annual feed budgeting. This shows that supplementation by protein source is required for reasonable livestock production. Natural pastures were observed to have significantly higher ($P < 0.05$) CP content as compared to straws and crop aftermath in the districts (Tables 5 and 6). A minimum of 15% CP is required for lactation and growth of ruminants (Norton, 1982) and hence the entire crop residues in the study area are by far below the requirement for production, indicating the need for supplementation of animal reared for the same purpose is compulsory.

In vitro dry matter digestibility

In vitro DM digestibility aftermath and wheat straw was 40.36 and 41.92% in Gasera district and 40.78 and

42.22% in Ginnir district, respectively (Tables 5 and 6). This is by far the lowest IVDMD of the major livestock feeds indicated in the table in the study districts. The percentage IVDMD for barley, emmer wheat, teff and pulses straw were comparable in both districts. The IVDMD was similar ($P < 0.05$) for barley, emmer wheat, teff and pulses straw, while the lowest was observed for wheat straw and aftermath among the crop residues. Lower IVDMD for aftermath and wheat straw in the area may be due to low leaf proportion for aftermath and prolonged time required for crop maturity for wheat compared to other cereals grown in the area that induces intensive lignifications. Mean IVDMD observed was within the range reported by Daniel (1988) and Gashaw (1992) for barley. Percent IVDMD observed was 64.87 and 69.55% in Gasera and 63.96 and 69.84% in Ginnir districts for grazing and fallow land, respectively. Among the crop residues, crop aftermath had the lowest (40.36 and 40.78%) IVDMD followed by IVDMD of wheat straw (41.92 and 42.22%) in Gasera and Ginnir districts, respectively.

Unlike CP content, mean IVDMD of pulse straw (54.44% and 51.60%) was statistically similar to that of cereal straws in both study districts. Variation of IVDMD was observed between crop aftermath and cereal straw rather than among cereal crops (barley, emmer wheat, teff and pulses except wheat straw) among straws of wheat, barley and emmer wheat. Crop residues with less than 50% OM digestibility reduce intake to 50 g/kg LW^{0.75} or less (Mosi and Butterworth, 1985). Thus, crop aftermath and wheat straw had less than 50% to limit feed intake, suggesting the need for either improvement of the nutritive value of these feed resources or supplementation with good quality feed for reasonable livestock production.

Fiber content of the major feeds

Neutral detergent fibre ranged from 66.23 to 79.85% for roughage feeds (natural grasses and crop residues in Gasera and 69.75 to 78.65% in Ginnir districts (Tables 5 and 6). The highest and lowest NDF content was recorded for crop aftermath and pulses straw, respectively in both districts of the study area. In general, NDF content is higher for crop aftermath and cereal residues, followed by natural grass and pulses straw with lowest content is from HMCs and wheat bran.

NDF contents of crop residues appeared to be close to the previous reports for central highlands of Ethiopia (Seyoum et al., 2001). Crop aftermath had significantly higher ($P < 0.05$) NDF content than pulses straw (Tables 5 and 6). However, variation in NDF content was not significant ($P > 0.05$) for natural pasture in the study districts. Generally, NDF content of roughage feeds with less than 45% was grouped as a high quality feed, while feed with NDF content of 45- 65 was categorized as

medium quality feed by Singh and Oosting (1992). Therefore, all crop residues had NDF content above 65% to be categorized under low quality feed that could affect livestock production.

The NDF content of roughage feeds that ranged from 66.23-79.85% in the study districts reported was to be high enough to limit DM intake and digestibility (Alemu, 1982). According to Van Soest (1985), NDF content above 55% was reported to limit DM intake and hence, NDF content of the natural pasture and crop residues in the study area could affect feed intake, which directly limits productivity of animals.

The mean maximum ADF content was 45.62, 56.34 and 51.71% DM for natural pasture (grazing and fallow land), crop aftermath and crop residues, respectively from both districts of the study area (Tables 5 and 6). ADF values for natural pasture was within the range of the report of Yihalem (2004) that ranged from 39.97-52.23% DM for the northern highlands of Ethiopia. The same author also observed increase in ADF as stage of harvesting advanced. The ADF content was significantly lower ($P < 0.05$) for natural pasture than either cereal straws or crop aftermath. However, the difference was not significant ($P > 0.05$) for straw and stubble (crop aftermath). Mean ADF content ranges from 48.45 to 49.82% DM for wheat, barley, emmer wheat and teff straw, where the minimum value is for barley and the maximum is for emmer wheat in Gasera district, while in Ginnir district it ranges 47.17 to 52.34% DM with maximum value for wheat straw (Tables 5 and 6). Pulses mean ADF content was 51.71 and 50.59% DM for Gasera and Ginnir districts, respectively. The ADF value obtained for crop residues in this study was comparable to the results of Yitaye (1999).

Lignin (ADL) content values was found for natural grass (5.65-7.82%), crop aftermath (11.24-11.77%), cereal straws (8.80-11.00%), pulses straw (12.72-13.64%) and available concentrates (5.11-6.26%) DM in the study districts (Tables 5 and 6). Lignin content was higher for straw of pulses as compared to that contained in cereal straws. This may be associated with varietal, climate and crop management differences in the area. Lignin content was significantly lower ($P < 0.05$) for natural pasture than either crop residues or crop aftermath which is comparable with that of available concentrates in the districts.

According to McDonald et al. (1995), in young pasture containing only 50 g lignin/kg, 80% of the fiber (cellulose and hemicellulose) may be digested but in older herbage with 100 g lignin in one kg, the proportion of the fiber digested may be less than 60%. Thus, lignin contents of the crop residues and aftermath in the study districts were high enough (above 7%) to limit DM intake and livestock production at the end. Relatively natural pasture in some of the wet months may had less than 5% lignin content, perhaps not to influence feed intake. However, the content went beyond 5% at the end of rainy season.

Table 7. Mean ME and DCP content of major sampled feed resources in the Gasera and Ginnir districts of Bale mid to highland areas.

Feed type	ME (MJkg ⁻¹ DM)		DCP (gkg ⁻¹ DM)	
	Gasera	Ginnir	Gasera	Ginnir
Grazing land natural grass	9.73	9.59	79.76	71.76
Fallow land grass	10.43	10.48	91.37	85.89
Crop aftermath	6.05	6.11	31.54	28.48
Wheat straw	6.28	6.33	26.43	28.15
Barley straw	7.24	7.47	33.77	32.94
Emmer wheat straw	7.16	7.22	32.84	32.56
Teff straw	7.03	7.38	31.63	31.64
Pulses straw	8.16	7.74	64.61	61.73

DM = dry matter; DCP = digestible crude protein; ME = metabolizable energy.

This is probably due to the positive correlation between lignifications and plant maturity (Reed et al., 1988), where maturity of the plant is accompanied by an increase in the fiber and lignin content of the plant.

Nutrient content estimation and implication on animal productivity

Estimation of major feed resources nutrient supply

Nutrient content of the major roughage feed resources per kg of feedstuff sampled in the Gasera and Ginnir districts are indicated in Table 7. The value of ME in natural grass (grazing and fallow land grass) ranged 9.59-9.73 MJ/kg DM for grazing land and 10.43-10.48 MJ/kg DM for fallow land grasses in the study districts. Content of ME in crop residues ranged between 6.05 for aftermath to 8.16 MJ/kg DM for pulses straw in Gasera and 6.11 for aftermath to 7.74 MJ/kg DM for pulses straw in Ginnir district. Seyoum and Zinash (1989) observed ME content of barley 7.8 MJ/kg DM, which was comparable with energy content of barley straw and other roughage feeds in the current study. For crop aftermath, energy concentration was the lowest value which was recorded in Gasera (6.05 MJ/kg DM).

Lower nutritive value of the crop residues in the study area may be related to the long period of time required for crop maturity because of erratic rainfall condition and other related factors. According to Preston and Leng (1984), the main sources of energy diet in crop residues are the cell wall constituents (cellulose and hemicellulose), which are not readily digestible (Tables 5 and 6). However, the same authors reported addition of a readily fermentable carbohydrate source to the roughage diets possibly increase the microbial biomass and rate of degradation of the fibers for continuous intake and supply of energy. Therefore, the ME content of feed in this study might not be adequate and readily available to animals

since the overall intake of the roughage feeds is low due to high fiber content and low CP content. Energy content of natural grass from fallow land in this study was similar to the energy content of similar feeds from the central highlands of Ethiopia and Sinana district of Bale highlands with 10.2 MJ/kg DM (Gashaw, 1992) and 10.80 MJ/kg DM (Solomon, 2004). Higher energy concentration of feed from natural grass (from grazing and fallow land) may be due to natural herbaceous legume mixed grass in the study districts particularly as observed in the fallow land grasses.

The DCP content of the natural grass (fallow and grazing land grasses) ranged 71.76 g/kg DM in Ginnir to 91.37 g/kg DM in Gasera for this particular study (Table 7). Mean DCP content of cereal straws was found within the range of 28.48 g/kg DM for crop aftermath to 61.73 g/kg DM pulses straw in Ginnir district while the DCP of feeds from Gasera district found within the range of 26.43 to 64.61 g/kg DM (Table 7). Digestible CP observed for pulses was the highest, which ranged from 61.73 g/kg DM (in Gasera) to 64.61 g/kg DM (in Ginnir). It was reported that nitrogen (N), but not energy, is the first limiting nutrient for animal performance (productivity) through the effect on feed intake and digestibility particularly during the dry season (Preston and Leng, 1984). In the study districts, the major feed resources during dry periods had low CP/DCP content (Tables 5 and 6) and, therefore, supplementation is required even to satisfy maintenance requirements of animals.

Annual nutrient yield estimation of major feed resources

Metabolizable energy available was 956,094.719 and 980,392.51 MJ per annum in the Gasera and Ginnir districts, respectively (Table 8). As the overall total ME supplied from the available feeds in the districts is comparable to each other, the same is true for the same

Table 8. Annual average ME and DCP supply from sampled major feed resources in the Gasera and Ginnir districts of Bale mid to highland areas.

Feed type	ME (MJ)				DCP (gm)			
	Gasera	%	Ginnir	%	Gasera	%	Ginnir	%
Grazing land grass	108,333.00	11.33	95,309.83	9.72	929,101.10	17.70	713,183.88	13.83
Fallow land grass	79,160.98	8.27	83,826.46	8.55	693,474.54	13.21	687,099.20	13.32
Crop aftermath	97,955.67	10.24	101,794.18	10.38	510,664.77	9.73	474,484.20	9.19
Wheat straw	396,042.54	41.42	390,025.35	39.78	1,666,784.16	31.75	1,734,472.93	33.62
Barley straw	174,066.25	18.20	187,362.91	19.11	811,908.47	15.47	826,202.72	16.02
Emmer wheat straw	26,234.95	2.74	34,332.04	3.50	120,329.04	2.29	154,855.56	3.00
Teff straw	20,999.80	2.19	35,963.25	3.67	94,484.18	1.80	154,183.93	2.98
Pulses straw	53,301.52	5.57	51,778.49	5.28	422,035.75	8.04	413,036.66	8.00
Subtotal of districts	956,094.71	100	980,392.51	100	5,248,782.00	100	5,157,519.08	100
Overall total		1,936,487.22				10,406,301.08		

DCP = Digestible crude protein; ME = metabolizable energy.

feed items from the two districts that they contribute almost comparable percent of ME. The annual ME supplied by wheat straw was high proportion (41.42% vs 39.78% in Gasera and Ginnir, respectively) since wheat is the major crop produced in the area. However, its utilization is negligible compared to other crop residues as indicated by the respondents and FGD participants. This might be because of its poor nutrient content and low palatability by the animals inherently. Whereas annual available ME from grazing lands was higher in Gasera district as compared to Ginnir. This is related to variation in the land use system and chemical composition of the feed resources in the area.

In general crop residues (aftermath and straw) contribute about 80.4 and 81.73% in Gasera and Ginnir, respectively of the total annual ME supply of roughage feeds in the districts with the inclusion of wheat straw (Table 8). However, in line with the utilization of wheat straw, farmers (FGD) underlined that, they used wheat straw as their animal feed when there are no other feed options in the area particularly during prolonged dry season. On the other hand the high proportion of crop residues utilization as animal feed in the study area indicate that high cropping intensity in the area. The overall ME supplied by crop residues of the total ME available in the study districts was higher than the contribution of crop residues (45-48%) observed in the highlands of Arsi (Abdinasir, 2000) and 55.75% reported by Solomon (2004) in Sinana-Dinsho district.

The annual mean DCP supply in Gasera and Ginnir was 5,248,782.00 and 5,157,519.08 gm, respectively (Table 8). The DCP supply was not statistically different in the study districts. This is probably due to relatively comparable feed resources availability in the area, which supplies CP to the equivalent extent either in content or bulkiness. It was estimated that crop residues supplied 70.97% of the available DCP including wheat straw in roughage feeds of both study districts where the

remaining was from natural grasses of different grazing lands.

Nutrient requirement for maintenance by livestock types were estimated based on the recommendations of Kears (1982) and McCarthy (1986) for tropical livestock unit (TLU). Annual DM, ME and DCP requirement for maintenance were 24,920.65 kg, 173,159.28 MJ and 1,697,268.80 gm, respectively in Gasera while it was 30,323.84 kg, 203,723.65 MJ and 1,980,976.54 gm, respectively in Ginnir area (Table 8). Dry matter available from major feed resources per household satisfied the maintenance DM requirement of livestock in the study districts according to the figure in Table 8. According to Ørskov and Ryle (1990), ME from roughage feed is less efficiently used due to low digestibility and voluntary intake than other feeds by the animals. Therefore, ME available is below the requirement for livestock production in the study districts, which implies an enormous requirement of fermentable feed supplementation for livestock, especially for production and other energy demanding activities accordingly.

Crude protein available from major feed resources was even deficient for maintenance in the study districts. Crude protein supply satisfied only the maintenance requirement of the animals in wet season when there is availability of green forages that are efficiently digestible by the animals. On the other side protein deficiency could also aggravate the problem of energy deficiency since both DCP and ME available in the feed are interrelated and affected each other through the activity of rumen microorganisms (Ørskov and Ryle, 1990). This suggests that, the need of supplementing animals with good quality feed even for maintenance, especially during the dry season (Table 4). In general, related to available feed resources, there is huge amount of poor quality roughage feed particularly crop residues that not permit the experts to say there is feed shortage in the study districts rather the bottleneck is feed quality which invites timely

intervention of all the concerned bodies for the betterment of future livestock productivity.

Conclusion

Natural grass, crop residues, crop aftermath and fallow lands were the major feed resource in both study districts. Productivity of livestock in the area is poor because available feed resources can't meet the nutritional requirement of livestock especially the content of protein is less than 7%, which did not meet, even the requirements of rumen microbes. Natural grass and fallow land grass contributed 18.94% and 29.03% ME and CP respectively and crop residues accounts 81.06% and 70.97% ME and CP respectively in both study districts. Season is a major factor that determines feed resource availability in the study area and during dry season animals face shortage of feed.

Therefore, based on the above conclusion the following recommendations are forwarded:

- i) The chemical composition of crop residue should be studied further at different level of crop management practices and at different cereal crop residue varieties because type of cereal crop variety, different level of management like pesticide and herbicide application have effect on nutritional value and palatability of cereal crop residue.
- ii) In order to compensate poor protein content of major feeds and to increase palatability of crop residue, it is better to give supplementary feeds and practice crop residue treatment (chopping and urea treatment) respectively.
- iii) Awareness should be given for farmers how to conserve forage to overcome feed shortage during dry season.

Conflict of Interests

The authors have not declared any conflict of interests.

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