Participatory Evaluation and Demonstration of Bagasse Ensiled with Wet Brewery Grain as Cattle Fattening Ration

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ABSTRACT

A farm participatory experiment was conducted to evaluate the effects of mixing and ensiling bagasse with wet brewery grain (WBG) and urea treatment of bagasses on chemical composition, nutrients utilization, shelf-life of WBG and economic feasibility as the fattening ration in peri-urban areas of East Shoa Zone. The evaluation was conducted on three different feeding treatments: bagasse ensiled with brewery grain and supplemented with concentrate mixed ration (CMR) (T_1), bagasse treated with urea and supplemented with CMR (T_2), and untreated bagasse supplemented with CMR (T_3). The concentrate mixed ration was composed of 49.0% nouge cake meal and 50.0% wheat bran, and 1.00% mineral mix, and it was through mixed and uniformly milled using the feed mixer. Farmers were organized in to three groups each contributing one fattening ox and under each feeding option a total of 5 animals were used. Significantly higher percentages of ash (Ash), crude protein (CP) were recorded for brewery grain ensiled bagasse than the other two groups. The dry matter (DM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) had decreased for brewery ensiled and urea treated than untreated bagasse while digestibility was enhanced for T_1 and T_2 than T_3 with highest record in T_1. Both T_1 & T_2 significantly ($p < 0.05$) increased intake of bagasse and total dry matter and average daily weight gain. T_1 was the most profitable, giving a net profit per animal of ETB 15,675, followed by T_2 with the least for T_3. In most livestock production systems fattening is one of the most profitable enterprises in Ethiopia, however, there was a large financial gain when the low quality feeds are improved with such techniques and supplemented with concentrate feeds. Ensiling brewery grain with bagasse can improve the nutritional quality of the basal diets and lowers the costs of fattening ration. The strategy demonstrated could be an alternative feed resource to tackle feed shortage if utilized by the Livestock and Fishery Development Sector.

Keywords: Bagasse, Brewery grain, Enisling, Roughage, Supplementation

INTRODUCTION

Beef cattle are among few agricultural commodities in Ethiopia from which the country earn foreign currency through both live and processed forms of the commodity export and also sources of livelihoods for most of rural resource poor farmers and pastoralists (EIAR, 2016; Shapiro et al., 2017; CSA, 2021). According to report of FAO (2020), the meat consumption of the country was about 8 kg per capita per year, of which about 4.3 kg comes from beef. This low level of meat consumption in Ethiopia is due to low level of meat production which in turn low productivity of the livestock sub-sector. The country has about 70 million cattle population and only a small fraction of Ethiopian beef is raised in feedlots (CSA, 2021). Smallholders throughout the country fatten the vast majority of cattle in backyard systems (EIAR, 2016; Belachew and Mebratu, 2019; FAO, 2020).

Several large scale meat processing abattoirs have been established in Ethiopia in response to the emerging meat export opportunities to the Middle East and North African countries (Harko H., 2015). These export abattoirs were also required to ensure a consistent and continuous supply of meat or live cattle in order to meet the demand of the customers in the importing countries. These developments are in the right direction to increase Ethiopia's foreign exchange earnings and improving the livelihoods of livestock producers and other actors engaged in the livestock related activities. Despite these opportunities, the potential of livestock sector in Ethiopia has not been fully utilized due to a number of complex and inter-related factors (Harko H., 2015; EIAR, 2016). The primary problem of beef production in Ethiopia is low quality and quantity of feed and their ever increasing costs throughout most periods of the year.

In most part of the country, livestock production is dominated by smallholder farmers with communal and small-sized private grazing areas. Such areas are characterized by an inadequate supply of feed, which is low in quality with low nitrogen and high fibre contents. Similarly, crop residues, which are other major sources of feed, are characterized by low nitrogen concentration, high fibre and low digestibility (Gemeda, 2015). Thus, these materials may be not sufficient to meet the maintenance and production nutritional requirements of the animal and, supplementation with nitrogen and energy is essential to improve palatability, intake, and rumen fermentation and improve beef production (Gemeda, 2015). On the other hand there has been development in sugar factories in Ethiopia in the last decades that produces a huge volume of molasses, bagasse and sugar cane tops which is not fully utilized as sources of animal feed.

Bagasse is the highly fibrous residue remaining after sugar-cane is pressed to remove sucrose. Sugar-cane mills produce more bagasse than can be utilized as a fuel source for sugar processing. Limited commercial uses for the excess bagasse have been developed and its accumulation presents a waste problem for the sugar factory. One potential use of bagasse is as a feedstuff for cattle; however, it has high in ligno-cellulose and lower ruminal degradability. In utilizing such resources the nutrients arising from rumen fermentation must be balanced using supplements containing dietary by-pass protein to provide essential amino-acids, energy sources for the synthesis of body tissues. Many reports that indicated ensiling such fibrous feeds with brewery grain can improve the nitrogen content, organic matter digestibility, and overall rumen fermentation (Akayeza et al., 1998; Kidist, 2019). In addition nitrogen content and ruminal fermentation can be improved by treating with urea.

Although there are a lot of research finding that has indicated the uses of such technologies for fattening potential there have been limited efforts to demonstrate for the end users. Thus, if such resources are treated with urea, ensiled with brewery grain they can be very good resources for fattening beef animals in Ethiopian meat industry. Thus, this study was executed to demonstrate and evaluate improving the nutritive value of bagasse and shelf life of wet brewery grain through ensiling techniques and its utilization as a part of fattening ration; and determine its effect on weight gain of animals and economic feasibility of using these technologies as compared to the conventional fattening rations.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted around peri-urban areas of Adama district of East Shoa Zone. There are many fattening small and medium scale fattening enterprises and the largest sugar factory is also found in this district. The study was located at 8°33`35``N - 8°36`46`` N latitude and

39°11`57`` E – **39°**21`15``E longitude about 99 km south-east of Addis Ababa (Figure 1). It is situated at an altitude ranging from 1400 to 2700 meters above sea level.

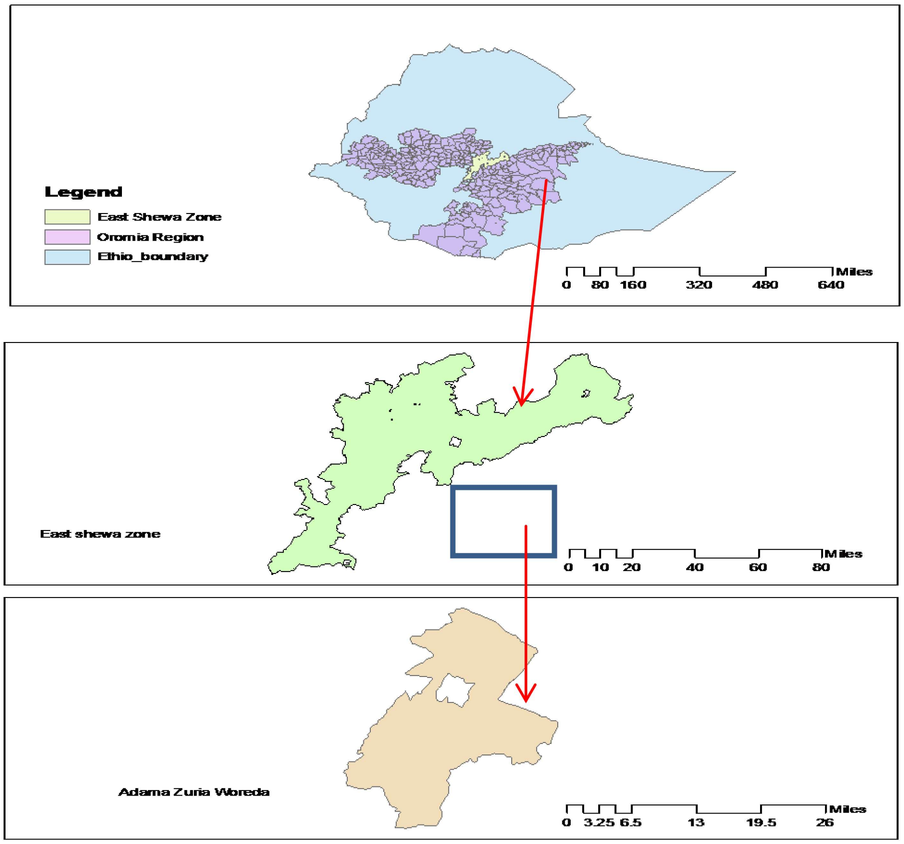

Figure 1 map of the study area

The area receives an average annual rainfall ranging from about 600 to 1150 mm which is erratic in nature. More than 67% of the mean annual rainfall occurs in the four rainy months: June, July, August and September. The minimum and maximum daily temperatures of the area are 12 and 33°C, respectively (ESZLFD, 2017). Cultivated land is approximately 439,120 ha. This area is known for its high production potential for crops such as teff, wheat, maize, barley, faba bean, emmer wheat, haricot bean, lentil, peas, sugar cane and livestock such as cattle, sheep, goat, horse, donkey and (ESZLFD, 2017).

Identifying the Potential Farmers

Purposive sampling technique was employed to identify the potential sites and farmers. Potential fattening farmers or peri-urban cooperatives near Wonji Sugar Factory were selected. It was conducted based on interest to fatten, and capacity to contribute one ox and interest to work together. Accordingly, 15 farmers were selected and involved in the participatory and demonstration experiment (Fattening Researcher Group- FRG) while 30 other farmers were also selected to involve in training and demonstration process (non- FRG). The formation of FRGs is one of good approaches that have been used in participatory evaluation and demonstration of agricultural technologies in our country. This is because such group formation can be a good linkage between research, extension and farmers, and thus the farming community can increase agricultural production efficiently by utilizing research outputs. Accordingly, a participatory meeting was made with farmers during the establishment of FRG's, the first being group discussion and sensitization training on farm level research that includes all stakeholders (extension workers, selected farmers for the FRG, and non- FRG) in the district.

Feed Preparation, Feeding, Sample and Data collection

Bagasse Treatment with Wet Distiller Grain and Urea

As per Memorandum of understanding of Arsi University with various industries, a linkage was established, so those FRGs had an access to the bagasse and brewery grain. The FRGs got the bagasse from Wonji Sugar Factory, all necessary inputs such as plastic sheet, feed ingredients, medicaments, urea, and brewery grain were purchased and the feeding diets were formulated provided by Arsi University.

The bagasse was ensiled with brewery grain. In the process 3 m X 4 m X 2 m sized pit was excavated and covered by thick plastic sheet in all sides to protect from moisture and soil contamination. Bagasse was thoroughly mixed with brewery grain and packed in to the pit by continually compacted manually to avoid air space. After filling the pit with bagasse-brewery grain mixture and packing, the pit was covered with plastic sheet and left for 21 days to be fermented anaerobically. With the same size for other group, bagasse was treated with urea in protected and covered pit with plastic until 21 days after which was used as a part of fattening ration. The concentrate mixed ration (CMR) was composed of 49% nouge cake meal and 50% wheat bran, and 1% mineral mix, and it was uniformly milled and thoroughly mixed using the feed mixer. The supplementary feeding levels (MCR) were set based on nutrient requirement (Kearl, 1982) and the prevailing season. The feed allowance was set, initially a maximum daily weight gain of 0.500 to 0.600 kg. The ration was also formulated considering to furnish 9.96 MJ of energy per kg of feed and to contain 18.2% total protein as recommended for feeding tropical breeds of animals (Kearl, 1982).

Animal Feeding and Management

Local breeds of worked oxen aged between five and six years were used for the experiment. Dentition was used to identify ages. During the experiment 15 animals were allocated in to three feeding treatments. Accordingly a group of 5 animals received of the three feeding treatments:

T1: Ensiled bagasse with brewery grain ad libitum 3 kg of CMR per animals

T2: Urea treated bagasse grain ad libitum 3 kg of CMR per animals

T3: Untreated bagasse and 3 kg of CMR per animals

Before the start of the actual experiment animals were treated for internal and external parasites and 15 days of acclimatization was used. The basal diets were provided on *ad libitum* basis while the mixed concentrate supplement was offered twice daily for the respective groups of animals; half in the morning and half in the afternoon. The animals were provided with tap water twice daily. Refusal feeds from each treatment group were collected and weighed every morning before the daily feed allowance was provided. The experimental animals were sheltered in the three groups during the entire experimental period.

Data and Sample Collection

The initial body weight of the animals was taken before the onset of fattening by using heart girth measuring tape. Heart girth of the fattening cattle was measured in the morning before offering feed. Before measuring, fattening cattle were restrained to stand squarely on all of the four legs. Data on body weight gain of fattening cattle was taken every 15 days. Heart girth measurement was used to estimate the body weight of fattening cattle as described by Goe et al., (2001). The measuring tape that was used in this experiment has heart girth measurement in centimeter and corresponding weight in kg developed by JICA project for Ethiopian cattle. The average daily body weight gain for each animal was determined as a difference between the final and initial bodies weights divided by the total number of actual feeding days.

All the daily offer and refusals were measured throughout the experimental period to calculate the intake. All variable costs such as animals cost, transportation cost for the oxen purchased, feed cost, labor and veterinary cost incurred to conduct this fattening trial for the above mentioned fattening period and other unforeseen costs were collected and recorded. The price of the fattened oxen at the end of the experiment was estimated by the experienced personnel by considering the existing body condition of animals. The physical characteristics of silage were assessed as described in Menesses, et al., (2007) while temperature was measured using thermometer.

Chemical Analysis and DM Digestibility Determination

The collected feed samples were transported to the laboratory where they were oven dried at (65^{o}C for 72 hr.). They were sent to Holeta Research center for all chemical composition analyses, the samples were ground to pass through a 1mm sieve in a Willey mill. The sample were be analyzed for dry matter (DM), organic matter (OM), Ash and N using the procedure of (AOAC, 2002). Nitrogen content of the feed was determined using kjeldhal procedure. The CP was computed as N *6.25. The NDF, ADF were analyzed according to Van Soest et al., (1991). The *in vitro* dry matter digestibility (IVDMD) content was determined according to Tilley and Terry's (1963) method.

Evaluation of Technology Diffusion

While demonstrating a given technology, we were facilitating the social aspects that particular technology thereby looks at how to facilitate better adoption of the technology. Accordingly, for certain technology to be better accepted, it should go through the process of diffusion of innovation model: this framework helps us to evaluate farmers' position towards that particular technology and predict its probability for better adoption. The major stages of diffusion model used in study were: knowledge and awareness, persuasion, decision, implementation and confirmation as described in JICA (2015). Training was provided for both FRG and non-FRG groups on feeds and feeding, beef animal production, beef value chain and marketing. The trainees, the fattening lots, and the ensiled feeds were frequently visited and followed up.

Data Management and Analysis

All data were recorded on well design formatted sheet and coded in excel sheet. The collected data related to feeding trial (body weight, feed compositions, DM and nutrient intakes) were analyzed using the GLM procedure of SAS (2009).

The statistical model was: $Y_{ij} = \mu + t_i + e_{ij}$,

Where

Y_{ij} = the observation ij,
μ = the overall mean,
t_i = the effect due to treatment i, and
e_{ij} = the experimental error.

RESULTS AND DISCUSSION

Physical Characteristics of Improved Basal Diets

The physical characteristics showed that the aroma of brewery grain ensiled with bagasse was sweet and vinegar taste which was a good characteristic of silage (Table 1). The quality of the ensiled material during the entire period was high, which was very pleasant from others. In the urea treated bagasse the physical examination showed that it was within the ranged of good quality urea treated feed. However, the oxen had shown more preference towards ensiled bagasse than the other treatments. Temperature was constant from day 0 to 90 days for all treatments similar to ambient, but after 80 days for ensiled and urea treated bagasse treatments, there was slight increase which was above ambient temperature. Penetration of air (oxygen) into the feed mass in the pit might result in growth of lactate-assimilating yeasts that had increased in temperature. Such scenario usually results in the growth of opportunistic bacteria and molds that thrive in oxygen cause more heating and spoilage. This had presumably happened as some of the farmers forget to cover the opened silo during feeding. Some research finding showed it is possible to extended shelf life of such silages up to 120 days (Moyo et al., 2016) effectively and about a year in well prepared silos. In addition in silage preparation, utilization and overall management was included in final training session and brochures were also provided for the farmers and development agents.

Table1. Physical characteristic of basal feeds (ensiled and urea treated bagasse)

Parameter	Treatments		
	T_1	T_2	T_3
Aroma	Very sweat and very pleasant	Sweet	-
Temperature	Ambient temperature	Ambient temperature	-
Palatability	Very good	Good	Poor

Chemical Composition and Digestibility of Improved Basal Diets

Treating bagasse with urea and ensiling with brewery grain had shown significant impact than the untreated bagasse on various nutritional parameters. The effect of WBG ensiling and urea treatment of bagasse on nutrient composition is shown in table 2. Significantly higher percentages of Ash and CP were recorded for WDG ensiled bagasse than the other two groups. The DM, NDF and ADF had decreased for WDG ensiled and urea treated bagasse than untreated bagasse. Digestibility was significantly improved for WDG ensiled and urea treated bagasse than untreated bagasse with highest record in WDG ensiled bagasse. The increased DM losses with T_1 and T_2 than T_3 could be probably due to the rapid fermentation of carbohydrates, mainly water soluble carbohydrates (WSC), which is the primary substrate for lactic acid fermentation. As brewery grain added to the bagasse and compacted, the moisture content also increased and the soluble sugars, proteins and minerals along with water, squeezed out due to packing pressure during ensiling. This might have resulted in losses of nutrients which are part of the OM (Charmley, 2004). In agreement with this study losses in DM concentration were also reported by many authors (McDonald *et al.,* 1991; Moyo et al., 2016; Kidist 2019). The increased in ash and CP content of silage with brewery grain inclusion might be due to the high concentration of N and different minerals present in brewery grain after ethanol extraction. This was in agreement with many authors (Anderson et al., 2009; Moyo et al., 2016).

Table 2. The effect of urea treatment and ensiling bagasse on nutrient composition and digestibility

Parameters	Treatments		
	T_1	T_2	T_3
DM	91.0^c	91.5^b	92.6^a
Ash	10.9^a	8.77^{ab}	8.5^b
CP	11.24^a	7.99^b	3.75^c
NDF	60.5^c	66.3^b	67.5^a
ADF	38.9^c	39.2^b	40.15^a
% DM Digestibility	62.5^a	55.5^b	45.5^c

Superscripts with different letters significantly differed across a row

The reduction in fiber components with inclusion of brewery grains and urea could be due to degradation of CF fractions of bagasse by the action of fermentative micro-organisms, and the subsequent utilization by microorganisms as an energy source. This generally improved Volatile Fatty Acid production in rumen which further improved Microbial protein in rumen and enhanced digestibility of structural carbohydrates as observed in this study (McDonald et al., 2011). Likewise, many authors also reported similar results (Schingoethe, 2004; Moyo et al., 2016; Kidist, 2019). The lowest DM digestibility was observed in untreated Bagasse (control diet) due to its high fiber content (NDF, ADF and ADL) and very low crude protein content. The amount of crude protein in Bagasse is too low to initiate rumen microbial fermentation. In addition the higher dietary NDF concentration is one of the important regulators of feed intake that determine energy yield, digesta flow and the so-called fill-limitation mechanism (McDonald et al., 2011) and thus lowered its nutritional quality. These factors had resulted in the lowest digestibility value for untreated Bagasse. However, as the Bagasse was treated with urea and ensiled with WDG grain the crude protein content increased and NDF decreased significantly though the improvement was the highest for Bagasse ensiled with WDG grain. This had resulted in increased digestibility and feed quality.

Effect of Feed Improvement on Weight Gain and Financial Gain

Both feeds improvement techniques significantly ($p < 0.001$) increased intakes of bagasse and average daily weight gain (Table 3). The change of trend in weight gain of animals is indicated in figure 7. The animal group under T_1 showed significantly ($p < 0.05$) the highest weight gain as the result of improved intake, digestibility, CP content, and enhanced fiber degradation and over-all DM digestibility. As the digestibility of a feed increases, the amount of energy available to the animal rises, therefore the animal weight gain improved. According to Allard (2009) improving digestibility as a result of decreasing NDF and CP contents can reduce CH_4 emitted per kg of production, thus, increased digestibility of diets often means fewer methane (CH_4) emissions per unit of production. Thus, it can be used as a mitigation strategy in reducing the impact of enteric methane (GHG) emitted from ruminants feeding low quality feeds in tropical conditions.

In the economic analysis (Table 3), T_1 was the most profitable, giving a net profit per animal of ETB 15, 675, followed by T_2 with the least for T_3. In most fattening situation, fattening is one of the most profitable enterprises in Ethiopia, however, there was a big financial gain when the low quality feed should be improved with such techniques and supplemented with TMR, if the animal has to be sold in a better condition with the highest financial profit.

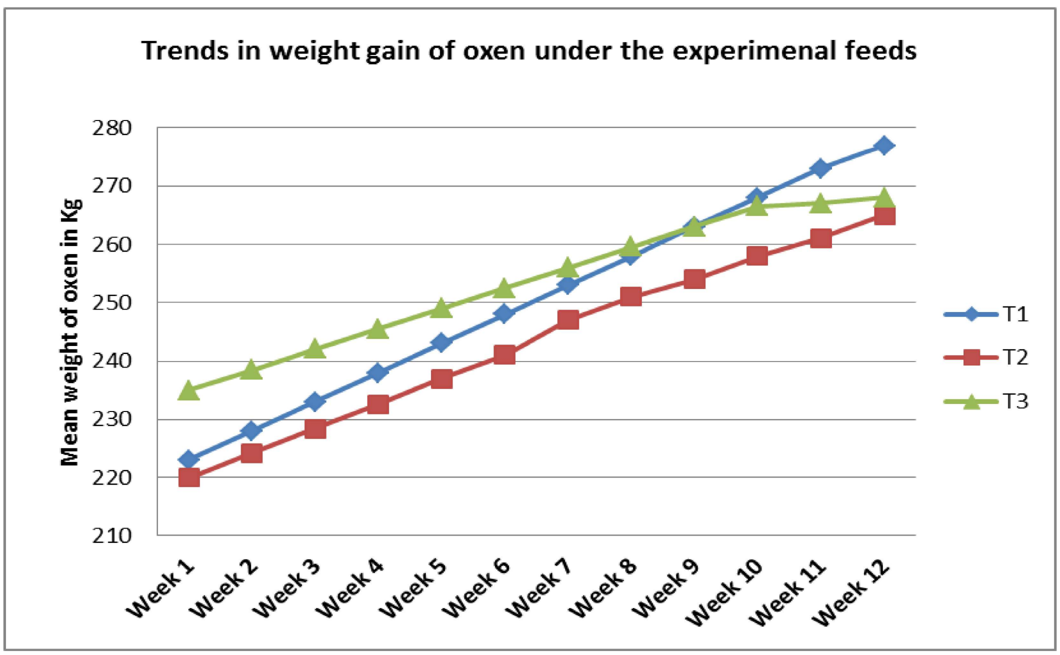

Figure 1. Trends in weight gain of oxen in the three treatments over the study period

Table 3.Weigh gain of animals and profitability of the experimental feeds

Parameters	Treatments		
	T_1	T_2	T_3
Average initial weight	223	220	235
Average final wt	277[a]	264.6[b]	268.3[ab]
Average wt gain	54[a]	44.6[b]	33.3[c]
Average purchase price	18500	19500	20,500
Feed cost	6750	6750	6750
Labour cots	4500	4500	4500
Drug cost	225	225	225
Average total cost	29975	30975	31975
Average sale price	45200[a]	43700[b]	40,000[c]
Value of dung	450	450	450
Total income	45650[a]	44150[b]	40450[c]
Net profit	15675[a]	13175[b]	8475[c]

Superscripts with different letters significantly differed across a row

In many Ethiopian farming systems, livestock were sold to escape deaths caused by drought, with low costs. In addition, cattle mostly were sold when they are old, culled, or unproductive, or when cash is required for unforeseen expenses. Although some farmer and pastoralist often sell animals targeting cultural or religious festivities, there are lower tendencies of intensive feeding to improve animal values (ESGPIP, 2011; Shapiro et al., 2017; Belachew and Mebratu, 2019). This might be due to lack of knowledge on market oriented production, the ever increasing feeds costs, financial problems, and access to market information that affects how livestock owners engage with the livestock fattening enterprises. This participatory experiment indicated that the utilization of Bagasse by improving its quality with treatment or ensiling can be one option for cattle fatteners.

Evaluation of Demonstrated Feeding Technology Using Diffusion Innovation Model

In this study, during demonstration of the technology to the farmers, the acceptance level of the three feed packages was evaluated towards the social aspects. Accordingly the process of diffusion of innovation model was used and the three feeding packages were then evaluated using this model approach. Forty five participants were visited the process, housing, feeding, ensiled feeds, animals body condition and also oriented with the fatteners explanations. They were individual fatteners, model farmers, none fattener groups (surrounding farmers), development agents and experts from agriculture office and extension professions.

The frequencies of farmers view towards the demonstrated technology are shown in table 4.The major stages of diffusion model were: knowledge and awareness, persuasion, decision, implementation and confirmation. The majority of the farmers viewed treatment 1 and 2 as very good with all model parameters except with knowledge and awareness which was rated as good. This might be due to the technique being newly introduced to them and it might take certain time for adoption. However, the majority of them decided to proceed with treatment 1 presumably due to its being observed higher consumption by the fattened animals and profitability.

Table 4. The frequency (%) of farmers view towards the demonstrated technology

Treatments	Model factors	Level (n=45)				
		Low	Satisfactory	Good	Very good	Excellent
1	Knowledge & awareness	0	0	66.7	33.3	0
Ensiled bagasse with brewery grain	Persuasion	0	0	22.2	66.7	11.1
	Decision	0	0	11.1	44.4	44.5
	Implementation	0	0	0	84.4	15.6
	Confirmation	0	0	44.4	44.5	11.1
	other factors	0	0	0	77.8	22.2
2	Knowledge & awareness	0	0	88.9	11.1	0
Urea treated bagasse	Persuasion	0	0	55.5	44.4	0
	Decision	0	0	33.3	62.2	4.44
	Implementation	0	0	20.0	66.7	13.3
	Confirmation	0	0	66.7	26.7	6.66
	other factors	0	0	0	77.8	22.2
3	Knowledge & awareness	0	0	77.8	22.2	0
Untreated bagasse	Persuasion	0	33.3	22.2	44.4	0
	Decision	0	44.4	33.3	4.44	0
	Implementation	0	26.7	62.2	6.67	4.44
	Confirmation	0	24.4	66.7	8.89	0
	other factors	0	33.3	55.6	11.1	22.2

***Knowledge and awareness**: it is knowledge about the technology's existence, sources, previous practices in the community) and (technical processes, procedures, inputs used)*
***Persuasion:** exposure to the technology, perceived compatibility, issues related with social rules.*
***Decision:** willingness to use the technology partially or fully*
***Implementation:** linking with farmers routine activities, gaining adequate knowledge*
***Confirmation:** devotion towards utilization of the technology with all its merits and cost implications)*
Other factors: (relative quality, suitability for storage utilization, easiness of making, relative palatability, for local condition, goodness of its prospects)

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Bagasse is one of the by-products of sugar industry and it is produced in large quantity by Wonji and Matahara sugar industries in East Shoa Zone of Oromia regional state. However, it has very low nutritive value. On the other hand wet brewery grain was also produced by alcohol industries in the same and neighboring zones and has a problem of shelf as it cannot stay more than 5 day maintaining its good quality, but it has appreciable amounts of mineral and protein contents. This experiment showed that by ensiling Bagasse with Wet Distiller Grain improved its crude protein content, digestibility and overall feeding value. In addition the shelf life of brewery grain was effectively improved to over three months. Thus, such techniques can be one of the solutions for feed related problems for cattle fatteners and dairy producers in the study and in similar farming systems.

Recommendation

Dissemination of such technologies is very important to address the feed related challenges of livestock production and productivity in areas and other farming systems. Thus scaling up of this technique is very important as this experiment engaged only 15 farmers. In addition farmers and fatteners should be linked with these industries to utilize such resources by providing appropriate training. It will be also important to consider such combinations of feed emergency during drought and this should be implemented by the Livestock and Fishery development sector.

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