Thesis Ref No: ___________

EFFECTS OF FEEDING UREA-MOLASSES, UREA-LIME AND EFFECTIVE MICRO-ORGANISM TREATED WHEAT STRAW BASAL DIETS ON FEED INTAKE AND GROWTH PERFORMANCE OF WEANED FRIESIAN- BORANA FEMALE CALVES AT HOLETTA RESEARCH CENTER, ETHIOPIA

MSc THESIS

By

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SEPTEMBER, 2021

BISHOFTU, ETHIOPIA

Effects of Feeding Urea-Molasses, Urea-Lime and Effective Micro-organism Treated Wheat Straw Basal Diets on Feed Intake and Growth Performance of Weaned Friesian-Borana Female Calves at Holetta Research Center, Ethiopia

A Thesis Submitted to the College of Veterinary Medicine and Agriculture, Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Masters in Animal Production

By

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BSc in Animal Production and Technology

September, 2021

Bishoftu, Ethiopia

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As members of the examining board of the final MSc open defense, we certify that we have read and evaluated the thesis prepared by Mr. Kedir Mohammed Aliyi entitled: "Effects of Feeding Urea-Molasses, Urea-Lime and Effective Micro-organism Treated Wheat Straw Basal Diets on Feed Intake and Growth Performance of Weaned Friesian-Borana Female Calves at Holetta Research Center, Ethiopia", and recommend that it be accepted as fulfilling the thesis requirement for the degree of Masters in Animal Production.

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DEDICATION

This thesis manuscript is dedicated to all my families and friends, especially for my father Mohammed Aliyi who dreamed my success when he was alive. It also dedicated to my favorite vocalist and activist Hachalu Hundessa and to all victims of **Covid-19** Pandemic all over the world especially for my former colleague Dr Muluneh Minta who passed away by this pandemic.

STATEMENT OF AUTHOR

First, I state that this thesis is my *bonafide* work and all sources of materials used for this thesis have been properly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is placed at the College Library to be made accessible to borrowers under rules of the library. I declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this work are allowable without special permission provided that accurate acknowledgement of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the College when his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however permission must be obtained from the author.

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BIOGRAPHICAL SKETCH

The author Kedir Mohammed Aliyi, was born in January 09, 1991 at Shashemane Woreda, West Arsi Zone, Oromia Regional State, Ethiopia. He attended his Primary Education at Wandare School from 2000 to 2007 and Secondary Education at Shashemane Burka Kero and Shashemane Preparatory School from 2008 to 2011. Then he joined Mekelle University College of Dry Land Agriculture and Natural Resource in 2012 and awarded BSc in Animal Production and Technology in 2014. Soon after Graduation, he was employed at Central Statics Agency Hawassa Branch and served for one Year. Then, he joined Ethiopian Institute of Agricultural Research (EIAR) and assigned to Holetta Agricultural Research Center in 2016 and served for three Years as Junior Researcher until he joined Addis Ababa University College of Veterinary Medicine and Agriculture to pursue his Graduate studies in Animal Production in October 2019.

ACKNOWLEDGMENTS

First and for most I would like to thank almighty ***ALLAH*** for creating me, supply me health, the internal strength and skill. Next, I would like to express my deepest thanks to my major advisor Professor Berhan Tamir for his unreserved technical advice, guidance, and follow-up during Proposal development to thesis write-up. I am also very grateful to my co-advisor Dr Getu Kitaw for his kind supervision and technical comments from the very beginning of proposal development to final thesis write up. My earnest thank is extended to the EIAR Livestock Research Director Dr Fekede Feyisa for his unreserved follow up and motivation.

I am also thankful to (EQUIP) -Strengthening Smallholder Livestock Systems for the Future project for financial support and Addis Ababa University for hosting me and financial support. My sincere thanks are also extended to Ethiopian Institute of Agricultural Research for providing me Education opportunity with sponsorship during my study leave and Holetta Agricultural Research center, especially dairy cattle breeding process coordinator Dr Ulfina Galmessa for allowing me experimental animals and feed. My special thanks also go to HARC animal feeds and nutrition research program, particularly to Mr. Deraje Fikadu for his generous assistances in the laboratory analysis and Mr. Kibrat Hailu for his assistance in the farm. I also thankful to HARC soil chemistry laboratory staffs for their kind support. My last but not list gratitude goes to My mother Subo Waritu who never forget me in any situation and My wife Samira Nagesso for unreserved backup and moral support during my study.

LIST OF ACRONYMS AND SYMBOLS

ADF	Acid detergent fiber
ADFD	Acid detergent fiber digestibility
ADL	Acid detergent lignin
ADLD	Acid detergent lignin digestibility
ANOVA	Analysis of variance
AOAC	Association of analytical chemistry
CaOH	Calcium hydroxide
CaO	Calcium oxide
°C	Degree silicious
CF	Crude fiber
CP	Crude protein
CV	Coefficient of variations
d	Day
DM	Dry matter
DMI	Dry matter intake
DOMD	Digestible organic matter digestibility
EIAR	Ethiopian Institute of Agricultural Research
EM	Effective Microorganisms
EM-2	Activated effective microorganism
EMTWS	Effective microorganism treated wheat straw
FAS	Foreign agricultural services
FAO	Food and Agricultural Organization
FCR	Feed conversation ratio
g	Gram

LIST OF ACRONYMS (Continued)

HARC	Holetta Agricultural Research Center
IVDMD	*In vitro* dry matter digestibility
IVOMD	*In vitro* organic matter digestibility
Kg^{-1}	Per kilogram
Mcal	Mega calories
ME	Metabolizable energy
mm	Mille meter
ml	Mille liter
N	Nitrogen
NH_3	Ammonia
NaOH	Sodium hydroxide
NDFD	Neutral detergent fiber digestibility
NDF	Neutral detergent fiber
NFE	Nitrogen free extract
NPN	Non protein nitrogen
OM	Organic matter
OMI	Organic matter intake
OMD	Organic matter digestibility
SD	Standard deviation
SNNP	Southern Nations Nationalities and Peoples
TDMI	Total dry matter intake
ULTWS	Urea lime treated wheat straw
UMTWS	Urea molasses treated wheat straw
UWS	Untreated wheat straw
VFI	Voluntary feed intake
WS	Wheat straw

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Effects of Feeding Urea-Molasses, Urea-Lime and Effective Micro-organism Treated Wheat Straw Basal Diets on Feed Intake and Growth Performance of Weaned Friesian-Borana Female Calves at Holetta Research Center, Ethiopia

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ABSTRACT

The study was carried out at Holetta Agricultural Research Center to evaluate the effects of urea-molasses, urea-lime and effective micro-organisms treatments on wheat straw quality parameters, and feed intake and apparent digestibility, growth performance and total feed cost of crossbred calves (3/4 Friesian X Borana). A completely randomized design was used for the laboratory trial. The randomized complete block design was employed to conduct the feeding and digestibility trial for over a total period of 104 experimental days . The dietary treatments were: - untreated wheat straw (T1), wheat straw treated with urea-molasses (T2), Urea-lime (T3) and activated effective micro-organism (T4). The result from the laboratory trial indicated that treatment options affected (P<0.05) the proximate , detergent and in vitro digestibility fractions with the highest crude protein (CP%) content being recorded for (T2 = 6.31%) followed by (T3 =4.88%). The values of NDF and ADF were reduced by effective microbial and urea-molasses treatment options. The highest (P <0.001) daily DM intake were recorded for calves that were receiving dietary T3 (3.7 kg/ head) and T4 (3.5 kg/head) than those receiving T2 (3.1 kg/head) and the control diet T1 (3.02 kg/head). Apparent dry matter and nutrient digestibility of the experimental calves fed treated straw were found to be highest (P<0.01) when compared to calves that were maintained on the control diet. Average daily gain of calves was significantly highest (p<0.001) for calves in T3 (422.7 g/d) and T4 (391 g/d) groups than those in T2 (281.7 g/d) and T1 (204.3 g/d) groups. Feed conversion ratios was observed to be higher (P<0.01) for calves in T3 (8.8 g feed/ each g gained) and T4 (9.4 g feed /each g gained) groups than those *on the control diets (15.1 g feed /each g gained). The total feed cost of calves maintained on the treated straw-based diets was significantly ($p<0.001$) higher than those on the control diet. The ratio of total feed cost to the live weight gain of calves were significant ($P< 0.05$) higher for T1 (110.8 birr/each kg gained) and T2 (109.6 birr/each kg gained) as compared to T4 (82.5 birr/each kg gained) and T3 (76.7 birr/each kg gained). Hence, it could be concluded that treating wheat straw using urea-molasses, urea-lime and EM could improve its nutritional values, improve growth performance cost-effectively when fed to crossbreed calves with concentrate supplemented at the rate of 1.2% of the calves' fortnightly weight changes. However, to draw valid conclusion further research needs to conduct to identify the optimum level of lime in the urea-lime combinations used for the crop residues treatment.*

Key words*: -* *Crossbred calves, straw treatment, feed intake, apparent digestibility, Wheat straw, live weight.*

1. INTRODUCTION

The primary constraint of livestock production in Ethiopia is the fluctuation in quantity and quality of animal feed supply. Among various reasons for this constraint, fast conversion of natural grazing land for crop production is the most important. Due to increase in human and livestock population, grazing land area per unit of animal is declining and putting substantial pressure on quantity and quality of feed resources (FAO, 2012; Getnet *et al*., 2016). Production of more food demanded by the increasing human population resulting rising contribution of crop residues as animal feed (Teshome, 2009; Sarkar *et al.*, 2020). As a result, crop residues are becoming an important source of livestock feed sources (Alemayehu *et al*., 2017).

However, available crop residues are underutilized due to its low feeding value (Teshome, 2009). According to CSA (2021), grazing is the major source of feed (54.54%) for livestock followed by crops residues (31.13%). To ensure proper utilization of feed resources, appropriate technological interventions need to be developed and transferred to user community (Getnat *et al.*, 2016). According to Adugna (2012), crop residues cannot satisfy even the maintenance requirements of animals without supplementation because of their low nitrogen, high cell wall and low digestibility values. Besides supplementation, various physical, biological and chemical treatment options have been investigated globally to upgrade the nutritional quality of crop residues (Getu *et al.*, 2011). Physical, chemical and physico-chemical treatments of crop residues is known to increase the intake, digestibility, and nutritional value of fibrous feed resources. The total production of straw and related materials has been calculated to be adequate to meet the maintenance needs of the ruminant. But the actual usage of straw as a livestock feed differs from one part of the world to another. Crop residues are vital feed resources for livestock in tropical and subtropical countries (McDonald *et al.*, 2010). Quality enhancement of crop residues using potential treatment options is aimed to the improvement of nutritional value, palatability, intake and digestibility of the feeds in low and middle-income countries (Mulubrhan *et* *al*., 2020). Utilization of low-quality roughage is difficult for ruminants due to its high level of fiber and low protein contents (Wenbin, 2016).

Wheat (*Triticum spp)* straw is the dominantly available crop residues in Ethiopia. Urea treatment has been practiced to improve the quality of crop residues in Ethiopia (Rehrhie and Ledin, 2004). Feeding urea treated straw was reported to reduce the need for concentrate supplementation through increased nitrogen content, improved palatability, digestibility and reduced animal weight during seasons of feed shortage (Dawit and Melaku, 2009). Treatment of wheat straw with urea and ammonium bicarbonate increased its CP from 3.2 (untreated) to 8.7% and 9.5% respectively (Amanat *et al*., 2002). It was also reported that urea-lime treatment increased CP, OM and also improved DMI and OMI as compared to untreated wheat straw (Can *et al*., 2004). According to Getahun (2014), CP% of wheat straw treated with 4% urea increased from 3.2%-6% and NDF reduced from 80.7% to 74.3% as compared to untreated and urea treated wheat straw, respectively. Treating wheat straw with urea (2%) plus lime (3%) showed significant improvement on nutritional contents, intake and digestibility (Ajebu *et al*., 2009). Lime treatment of straw also removes lignin and improves cellulose digestion by enzymes through opening up the structure (Mushi, 2016). However, there is very limited information on the comparative biological and economic responses of dairy heifers fed wheat straw treated with various treatment options in Ethiopia.

Therefore, this study was initiated with the following objectives:

- Determine the chemical compositions of wheat straw treated with urea-molasses, urea -lime and effective microorganism solution

- Determine the feed intake, apparent digestibility and growth performance of weaned (Friesian-Borana) female calves fed wheat straw treated with urea-molasses, urea -lime and effective microorganism

- Analyze feeding cost of weaned (Friesian-Borana) female calves with wheat straw treated with urea-molasses, urea -lime and effective microorganism.

2. LITERATURE REVIEW

2.1 Feed Resource Base in Ethiopia

Livestock production in Ethiopia has a significant importance at household level and for the national economy. However, the productivity is much below the potential due to poor nutritional quality (Adugna, 2012). According to the current reports of CSA (2021) feed resources utilization in Ethiopia, grazing is still the main type of feed (54.5%) followed by crops residue (31.1%). Hay (7.4%) and By-products (2%) were also used feeds resources. Cereal crop residues have the highest contribution to the total feed supply starting from harvesting of food crops to the wet periods during the time at which feed from grazing areas is inadequate or almost unavailable (Adugna, 2012; Alemayehu *et al*., 2017 and Aranguiz and Creemers, 2019). Straws are being used as a livestock feed ever since the beginning of cereal cultivation as they are certainly produced as cereal by-products (Mahesh and Mohini, 2013).

2.2 Availability of Crop Residues in Ethiopia

Fibrous agricultural residues are the most important options to tackle feed shortage in the highland areas where crop production is taken as cultural and economic values (Habte *et al*., 2019). Crop residues are used to their best potential under proper storage so that the livestock have an adequate supply throughout the dry season where the fodder is inadequate (Bhandari, 2019). Cereal sources of straw include; wheat straw, barley straw, teff straw, rice straw, maize stover, sorghum stover, millet stover and oat straw. But legume straws include groundnut, chick pea, pea, soybean and the dried stalk materials contain a higher nutritional value than cereal crop residues. Similarly, sweet potatoes, cassava tops and vines, sugarcane tops and ensat by-products are very important in livestock production systems (Adugna, 2012). The availability of fibrous crop-residues determines livestock production per unit area of land than roughages and concentrates availability.

2.3 Wheat Straw Production and Utilization Potentials in Ethiopia

Wheat (*Triticum spp.*) is one of the most important cereals grown in the high- and mid-altitude regions of Ethiopia (Karta, 2019). Straw is the stems and leaves of small cereals left after the grain harvest usually over half of the harvestable vegetation of the crop. Wheat straws are source of animal feed in wheat-growing countries like Ethiopia and also used as a roof tacking material (Adugnaw and Dagninet, 2020). According to FAO (2018), Wheat straw availability is higher (16%) next to maize (39%) and sorghum (21.7%) in Oromia. Oromia is the most potential producer of wheat in Ethiopia and followed by Amhara and SNNP regions in terms of both total production and area coverage (Adugnaw and Dagninet, 2020).

2.4 Nutritive Values of Crop Residue

Nutritive value of crop residues can be determined by nutrient composition, intake and utilization efficiency of digested matter. Crop residues are most important in contributing to livestock feed but they tend to be of low quality (Fentahun *et al.*, 2020). According to Alemayehu *et al*. (2017), the CP content of crop residues ranges from 2.4-7% and IVDMD of straw is between 34 and 52%. They are also characterized by high amounts of cell wall and cell wall constituents. Energy from diet is mainly gained from fermentation of the plant cell wall by rumen microorganisms. Cell walls of crop residues consist mainly of polysaccharides, protein and lignin. Proteins make up 2-10% of the primary cell wall and lignin represents between 5-20% of crop residue DM (FAO, 2002). The chemical structure of cellulose is a linear polysaccharide polymer consisting of thousands of glucose monosaccharide units connected by beta-acetal linkages (Peterson, 2014). It is also not palatable and its daily intake is very low usually less than 15 g DM/kg live weight (Owen, 1994). The value of a feed depends on chemical composition, digestibility, intake and efficiency (FAO, 2002). The average IVDMD of cereal crop residues is about 48%, which is lower than the minimum level required for quality roughage (Seyoum and Fekede, 2003). But, crop residues are potentially rich sources of energy because up to 80% of their DM consists of polysaccharides (FAO, 2002).

A variety of factors have been identified to influence nutritive value of crop residues. These, factors can be divided into three categories: plant, animal and environmental. Species of plants, stage of maturity at harvest, cultivars and leaf to stem ratio are important plant factors determining their nutritive value (Van Soest, 1988). The lignin fraction and associated phenolic compounds are factors most consistently associated with the rigid structure of plants and limited accessibility to microbial digestion in the rumen. The association of lignin with cell wall polysaccharides is also believed to be responsible for resistance of plant cell walls to microbial digestion in the rumen (FAO, 2002). More lignified plants are considered ideal for chemical treatment since no benefits of chemical treatment have been observed with cell soluble (Peterson, 2014). Ruminants are known for their ability to utilize materials and roughages of little values due to the presence of microorganism in their rumen that can degrade fibrous materials (Millam, 2016).

Fibrous matter retain in the cattle rumen slightly longer than sheep or goats, this probably have an advantage with lower quality roughage (FAO, 2002). Some environmental factors, including location, climate, soil fertility and soil type, seem to influence the nutritive value of crop residues. For instance straw from wheat grown in the so-called flow soils had considerably higher CP content and lower fiber (NDF, ADF and ADL) content than straw from plain soils (FAO, 2002). Study showed that the quality of crop residues which is naturally low would be affected by storage especially when stored in open air. The CP, IVOMD and ME contents of crop residues reduced with prolonged storage. But, the fiber fraction of crop residues increased with increasing storage (Fekede *et al.*, 2015).

2.5 Nutritive Values of Wheat Straw

Wheat straws are considered to be lower in nutritional value than barley straw. However, its digestibility can be markedly improved with alkali treatment (McDonald *et al.,* 2010). Wheat straw holds 3.40% CP, 75.8% NDF and 50.7% ADF (Dereje *et al*., 2017). Most cereals crop residues has very low digestibility for instance wheat straw 45% (Getnet *et al.*, 2016).

2.6 Crop Residue Improvement Options

The fundamental principles of crop residue treatments are the aim to break or solubilize the chemical and physical bonds in cell walls. This can be attained by using physical and chemical treatments options or their combination (Sharma *et al.*, 1995). Crop residue treatments could be broadly classified as chemical, physical and biological treatments (Wenbin, 2016).

2.6.1 Effects of physical treatment on nutritive value of crop residues

Physical treatments include mechanical treatments, such as grinding, chopping, pelleting or soaking and thermal treatments. Grinding and/or pelleting leads to a reduction in particle size, and increase in surface area and density. These changes increase in voluntary intake, a reduction in digestibility and increase in the efficiency of the utilization of metabolizable energy (FAO, 1985). Mechanical treatments are reducing the roughage size to improve the feed intake by animals (Wenbin, 2016). The physical treatment methods like steam are obviously limited to industrial conditions where steam is available. But, other physical methods like chopping can employ machines or hand labor depending on the relative availability of labor (Sharma *et al.*, 1995). Rolling straw with green fodder is traditional method of treatment in China. It is used to maintain green fodder with high quality, increase palatability and nutritive values of straw (Gao, 2000).

2.6.2 Effects of chemical treatment on nutritive value of crop residues

Since the beginning of the 19th century, efforts have been made to improve the digestibility and nutritive value of crop residues (Millam, 2016). Alkali treatment of straw hydrolyzed the ester linkages between lignin and the cell wall polysaccharides, cellulose and hemicelluloses that make the carbohydrates to become more available to the microorganisms in the rumen. This effect was first used to improve the digestibility of straw in Germany in the early 1900s, by a process that involved soaking straw in a dilute solution of sodium hydroxide (McDonald *et al.,* 2010). The purposes of chemical treatments are to decrease the rigidity of the cell structures and cell walls (Wenbin, 2016). Among many chemicals that have been screened for their potential to enhance digestibility, only three namely sodium hydroxide (NaOH), ammonia (NH_3), and calcium hydroxide $(CaOH)_2$ are being routinely used in animal research (Millam, 2016).

Sodium hydroxide treatment: In the 1920s, Beckman, a German scientist, successfully used sodium hydroxide to treat stalks and greatly improving digestibility (FAO, 2002). Sodium hydroxide has been reported to have high potential for improving the chemical content of straw. This is because NaOH treatment hydrolyses most of ester bond leading to release of acetyl group (Mushi, 2016). The main shortcomings of alkalization are its high cost and pollution (FAO, 2002). Similarly, the chemical is difficult to handle and not widely available (Sharma *et al*., 1995). Its application procedure basically followed the dry method, where NaOH is applied at 3-5% and the moisture content is 20-30% of DM. Through, these affect structural carbohydrates in both lignified and undignified plant tissues, with consequent increases in rate and digestibility (Millam, 2016). Long-term accumulation of sodium may lead to soil fertility problems and environmental pollution. Thus, application of NaOH treatment of crop residues is not popular with the farmers at present (Millam, 2016).

Lime treatment: Calcium hydroxide, commonly called hydrated lime or slaked lime, is produced by adding water to calcium oxide in a controlled reaction. Moreover, the heat energy CaO produced when forming the hydrated Ca $(OH)_2$ in water is favorable for reaction acceleration (Mushi, 2016). Lime (CaO/Ca $(OH)_2$) is a weak alkali agent with a low solubility in water. Soaking and ensiling are two methods of treating straw with lime. However, mold growth was noticed in the Ca $(OH)_2$ treated straw (Mushi, 2016).

Compared to untreated treating with 5% CaO improved IVOMD of cobs, wheat straw, and corn stover by 9.0, 14.3, and 10.1%, respectively (Shreck, 2013).

Urea-lime treatment: Urea-lime mixture would be able to combine treatment effects on both chemicals together with the added calcium and nitrogen in the straw and thus increased digestibility (Mushi, 2016). In such a combination either residual NH_3 or Ca would be necessarily as high as if the chemicals were used alone. However, the combination of 3% lime and 2% urea can be biologically justified, at least as an alternative to 4% urea alone, for straw treatment (Trach, 2001; Millam, 2016). When 3% lime is used high alkalinity can be induced by lime, a high level of urea as an alkali is not important for effective treatment (Trach, 2001). It was suggested that a combination of lime and urea would give better results than urea or lime alone (Millam, 2016). More over the optimum moisture content of ensiled crop residues and treatment period is 500 g/ kg and 3 weeks produced satisfactory results (Zaman *et al*., 1994). According to the same author increasing the Ca $(OH)_2$ level to 6% straw (DM) gave linear improvement in digestibility and 1.5% urea to straw DM in combination with Ca $(OH)_2$ could be used to prevent mold formation. The experiment done on Yankasa rams in Nigeria revealed that treatment of groundnut shells with 2.5% urea and 2.5% lime in total mixed ration improved CP intake by 5.7g/day, DMD by 7.4% and CP digestibility by 4.0% (Millam *et al*., 2017).

Urea-molasses treatment: Molasses is by-product of the sugar beet and sugarcane industries. The additive has been shown to increase the dry matter and lactic acid contents, and to reduce the pH and ammonia levels in treated silage (McDonald *et al.*, 2010). Molasses is a source of readily fermentable energy and also important to improve the taste of the basal feed. A molasses feeding is economically successful since rates of animal performance and efficiency of feed utilization is almost doubled compared with the traditional feed (FAO, 2002). Study done on finger millet straw treated by urea-molasses improved the CP content from 2.13% to 9.7% (Degitu *et al*., 2020). Addition of molasses to urea facilitate the microbial activities by ensuring supply of carbon skeleton from readily fermentable energy source and N unit from ammonia (Sarwar *et al.*, 2011). Urea-molasses treated maize stover diet slightly improved growth of dairy cows and contributed to an increase in DMI (Mudavadi *et al*., 2020). The total DM, CP, and OM intake were showed significant improvement in lambs assigned in urea molasses treatment than the control groups (Degitu *et al.*, 2020). Treated crop residues with urea-molasses shows a significant improvement in chemical composition and fermentation products (Mudavadi *et al*., 2020). But, the study done on sheep fed urea or urea-molasses treated maize stover showed no improvement on feed intake and digestibility without concentrate supplementation (Fitsum *et al*., 2018).

Urea treatment: In the process of urea treatment, formation of ammonia from urea by ureases enzyme in the ensiling process hydrolyses the bonds between lignin, cellulose and hemicelluloses in the plant cell wall and makes them more accessible to microorganisms in the rumen and increases total fermentation (Millam, 2016; Aruwayo, 2018). Ureolysis is an enzymatic reaction that requires the presence of the urease enzyme in the treatment medium. The moisture content of urea treated roughage should not be less than 30%, and not greater than 60%. Below 30%, ureolysis can be severely reduced or even not take place (Wanapat *et al*., 1996). Urea treatment is chemical treatment of forages that is easier to handle, and often cheaper, than ammonia. When exposed to the enzyme urease, urea is hydrolyzed to yield ammonia (McDonald *et al.*, 2010).

$$NH_2—CO—NH_2 + H_2O \longrightarrow 2NH_3 + CO_2.$$

Feeding urea treated straw reduces the need for concentrate supplementation and decrease weight loss during seasons of feed shortage (Dawit and Melaku, 2009). Urea treatment improves voluntary intake of the treated straw as compared with the untreated straw when it is fed *ad libitum*. The author also stated that animals fed the urea treated straw gained 0.21 kg/day while those that fed the untreated straw lost 0.13 kg/day (Aruwayo, 2018). The study reported by Akraim *et al*. (2009) revealed that treatment of straw with urea has elevated it’s CP content from 2.6% in untreated to 12.88% in treated straw. Similarly, urea treatment increase the CP content of maize Stover by 380% folds over the untreated Stover and improved the IVDMD and DMI of the calves fed Stover by 9 and 22%, respectively (Tesfaye, 2006). Urea treatment process is increased nutritive value through increasing forage digestibility by as much as 8 to 10 points, CP by more than double and intake by as much as 25 to 50% (Egbu, 2014).

Urea application rates on straw treatment have led to numerous controversial discussions concerning optimum rates. However, it is now well established that the optimum application rates lie between 4 and 6 kg of urea per 100 kg of straw (Getu *et al*., 2011). According to Tesfaye (2006) the ADG of cross breed calves fed untreated and urea treated maize Stover were 284 and 385 g/d respectively. Urea treatment by different level (2%, 4% and 6%) increases the CP contents of groundnut 7.81, 10.22 and 10.24 respectively (Hameed *et al*., 2012). Urea treated finger millet straw increases CP content from 4.3 to 7.4% (Gashu *et al.*, 2017). The CP content of barley, teff and wheat straw from 3.68, 3.07 and 2.41 before treatment to 6.98, 7.65 and 7.25 after treatment (Getu *et al*., 2011). The treatment of rice straw and local grass with urea increased CP content from 3.2% to 7.1% and 3.4% to 8.3% (Parmar *et al*., 2017). Study also shows that urea treated maize Stover seems to be useful to improve the CP (4.31-9.98%) and also little changes on other components of maize stover (Elias and Fulpagare, 2015).

2.6.3 Effects of biological treatment options on nutritive value of crop residues

The role of biological treatments is breaking the lignocellulose complexes by fungi and/or their enzymes to release free cellulose to upgrade roughage feeding value (Wenbin, 2016). Effective micro-organisms **(**EM) mutual with nature farming and environmental development that is of low cost, safe and effective. Biological performances of Animals fed with EM probiotics were significantly improved (Tadessa *et al*., 2012). Uses of effective microorganism in agriculture release nutrients from organic matter, enhanced photosynthesis and protein activity (Renuka and Parameswari, 2012). Study done on beef cattle feed on treated wheat straw showed that mean values for daily live weight gain calculated was 672, 1201 and 1164 g/d for the untreated, 5% urea and microbial treatment respectively (Weixian *et al*., 1995). The CP content of finger millet straw treated with urea molasses and EMO was increased from 2.13%-9.7% and 2.39% respectively and likewise it was showed improvements on feed digestibility, feed conversion efficiency and body weight gain (Degitu *et al*., 2020). Barley straw treated by EM and supplemented with concentrate mixture increased feed intake and milk yield of the cows (Girma and Alemayehu, 2018). The study done on coffee pulp ensiled with EM as biological inoculants showed improvement in the overall nutritive value of wet processed coffee pulp as observed from silage quality, chemical composition and *in-vitro* dry matter digestibility (Yonatan *et al.,* 2014). White rot fungi are the commonly used biological treatment of crop residues. It improves CP, digestibility and break the ligno-cellulose complexes, liberating free cellulose (Mahesh and Mohini, 2013). Chemical composition of treated and untreated common crop residues used in Ethiopia are shown in the Table 1 below.

Table 1: Chemical composition of selected crop residues treated with urea-molasses, urea-lime and EM in Ethiopia

Crop residues	Treatment	level	%DM	Ash	CP%	NDF%	ADF%	ADL%	References
	Untreated	-	92.7	9.6	3	74.3	49.5	5.2	
Wheat straw	Urea-lime	2 +3 kg	56.1	13.2	4.5	71.3	50.2	6.4	Ajebu *et al.*, 2009
	Untreated	-	93.8	7.70	1.65	83.0	65.2	-	
Wheat straw	EM	1-1.5 lt/kg	92.2	9.18	2.07	77.9	52.2	-	Getu *et al.*, 2016
	Untreated	-	88.6	9	3.2	80.7	52.3	7.5	
Wheat straw	Urea	4 kg	69.9	9.6	6	74.3	50.4	7.0	Getahun, 2014
	Untreated	-	93.5	7.59	2.74	79.6	64.1	-	
Barley straw	EM	1-1.5 lt/kg	92.9	9.32	3.13	75.1	55.5	-	Getu *et al.*, 2016
	Untreated	-	89.7	7	4.44	74.4	67.8	12.1	
	Lime	3 kg	76.6	13.4	4.01	70.1	59.6	10.2	
Sesame straw	Urea-lime	4+3 kg	76.2	13.8	7.88	67.9	60.6	12.7	Teferi *et al.*, 2014
	Untreated	-	90.8	6.7	5.9	85.5	54.7	5.2	
	Urea	4 kg	71.7	17.5	8.6	80.4	52.2	4.1	
Maize stover	Urea-molasses	4 +10 kg	63.7	17	10	80	50.1	4.0	Fitsum *et al.*, 2018
	Untreated	-	93.10	8.81	1.92	80.7	63.9	-	
Oat straw	EM	1-1.5 lt /kg	91.40	10.60	2.20	76.8	57.8	-	Getu *et al.*, 2016
	Untreated	-	92.23	7.20	2.92	77.77	54.97	9.63	
	EM	0.45 lt /kg	96.43	9.17	5.33	73.83	51.20	8.50	
Sorghum stover	Urea	5 kg	95.20	8.30	12.97	72.23	56.60	11.10	Daniel *et al.*, 2016
	Untreated	-	91.90	18.20	3.46	69.10	43.70	4.10	
	EM	0.6	92.8	21.3	4.98	56.3	41.0	4.9	
Rice straw	Urea	5	92.8	23.3	5.51	68	46.1	6.4	Lamma & Endalew, 2017

DM=dry matter, CP= crude protein, NDF= neutral detergent fiber, ADF =Acid detergent fiber, ADL= acid detergent lignin, Kg= kilogram, lt-^{1}kg =liter per kilogram, EMO=Effective Micro-organis

2.7 Response of Wheat Straw to Treatment Options

2.7.1 Effects of treatment on chemical compositions of wheat straw

According to Getu *et al.* (2016) the chemical composition (CP, NDF, ADF) and *In vitro* OMD of wheat straw treated by EM significantly affected as compared to untreated wheat straw. Similarly, wheat straw treated with 4% urea affects the content of CP (3.2% vs 6.0%), NDF (80.7% vs 74.3%), ADF (52.3% vs 50.4%) and ADL (7.5% vs 7.0%) untreated and urea treated wheat straw respectively (Getahun, 2014). Moreover, treatment of wheat straw with 4% NaOH improved DM, cellulose, and hemicellulose digestibility in the lamb digestion trial and OM was increased from 51.3% for untreated wheat straw to 65.3% for (Lesoing *et al.*,1981). Treated wheat straw can be replace up to 70% of the ration for small ruminant at maintenance or with low gain (Kraiem, 1991). As reported by Amanat *et al.* (2002) treatment of wheat straw with urea and ammonium bicarbonate increased its CP from 3.2-8.7% and 9.5% respectively. Treated wheat straw with urea and ammonia increases CP from 2.8-6.9 and 5.7% respectively (Kraiem *et al.*, 1991). Similarly, Wheat straw treated with 4% urea had reduced NDF from 80% to 77% by addition of 6% acidified molasses improved NDFD from 47.33% to 50.04% (khan *et al.*, 2006).

2.7.2 Effects of wheat straw treatment on feed intake, digestibility and growth

Treatment of wheat straw by urea (2%) plus lime (3%) showed significant improvement on chemical composition, intake and digestibility of sheep fed treated wheat straw with urea-lime (Ajebu *et al.*, 2009). Lambs fed chemically-treated wheat straw gained significantly faster and more efficiently and consumed more dry matter per day than those fed untreated wheat straw diets (Lesoing *et al.*, 1981). The same author stated that *in vitro* dry matter disappearance (IVDMD) of wheat straw was increased 29% by chemical treatment with 1% NaOH plus 3% Ca $(OH)_2$ and by as much as 86% by a 4% NaOH plus 1% Ca $(OH)_2$ treatment. *Ad libitum* intake of treated wheat straw with urea increased daily weight gain with range of 75 to 290 g in feeding growing bulls trails (Flachowsky *et al.*, 1996).

3. MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in Holetta Agricultural Research Center (HARC) dairy farm. The center is located at 29 km west of Addis Ababa at latitude of 9º 00' N and 38º 30' E longitudes. The study area has an altitude of 2400 meters above sea level and receives mean annual rainfall of about 1144 mm. The mean minimum and maximum temperatures are 6°C and 22°C, respectively. The soil types in the area are nitisol and vertosols. The major crops grown are tef, wheat, barley, oats, potatoes, oil crops and pulses (EIAR, 2021).

3.2 Experimental Animals and Treatments

A total of twenty-four weaned 75% (Holstein Friesian-Borana) crossbred female calves weighing 99.3±19.7 kg and aged 6 to 9 months were selected for this study from Holetta Agricultural Research Center dairy farm. The experiment took a total of 104 days including 14 days of adaptation and 90 days of data measurement period. The calves were dewormed for internal parasites three weeks prior to start of the experiment. The experimental animals were blocked in to six blocks based on their initial body weight and assigned to one of four dietary treatments using completely randomized block (RCBD) design with six calves used per treatment as replicate animals, and the four dietary treatments were:

T1: Untreated wheat straw (WS) *ad libitum* plus concentrate supplemented at 1.2% of the calves' live weight

T2: Urea (5%) plus molasses (10%) treated wheat straw (UMTWS) *ad libitum* plus concentrate supplemented at 1.2% of the calves' live weight

T3: Urea (2.5%) plus lime (2.5%) treated wheat straw (ULTWS) *ad libitum* plus concentrate supplemented at 1.2% of the calves' live weight

T4: Effective Micro-organisms (500 ml kg^{-1}) treated wheat straw (EMTWS) *ad libitum* concentrate supplemented at the rate of 1.2% of the calves' live weight.

3.3 Experimental Feed Preparation and Feeding Management

The basal diet used in this experiment was wheat straw of variety *Danda'a* which was collected in January 2021 after grain harvest from on station plots available at Holetta Agricultural Research Center. The straw was baled and stored in the center's hay barn. Part of the stored wheat straw was chopped to 5-10 cm (Figure 1) before subjected to the various crop residue treatment options.

Figure 1: Chopping baled wheat straw

For calves in the first treatment group, the wheat straw was left untreated but was chopped to 5-10 cm length before it was fed to the animals. Urea-molasses treated wheat straw used in the T2 group was prepared according to the procedure outlined by Sundstol and Owen (1984). Urea-molasses solution was prepared from 5% of urea and 10% of molasses and allowed to completely dissolve in 80 liters of water. The solution was uniformly sprayed over 100 kg of air-dried wheat straw at the rate of 800 ml kg^{-1} straw mass. To prepare urea-lime treated wheat straw for feeding calves in the T3 group, the solution was prepared from a mixture of 2.5% urea and 2.5% quick lime and allowed to completely dissolve in 80 liters of water. The solution was gradually sprayed on the straw at the rate of 800 ml kg^{-1} dry straw mass to achieve appropriate moisture contents in the final treated straws as recommended by Millam *et al.* (2017).

In the last treatment (T4), wheat straw was subjected to treatment prepared from a solution containing a blended mix of essential microbes called Effective micro-organism. Adequate quantities of activated effective microbial solution also called EM-2 was purchased from Weljijie private limited company located at Bishoftu. The extended EM was sprayed directly on the wheat straw sample in a batch at the rate of 500 ml kg^{-1} straw mass, compressed in a well-prepared silo, sealed and finally allowed to ferment for about 21 days. The extended EM was prepared from the activated EM following the procedure that outlined by Tibebu *et al.* (2018). According to the procedure one liter of EM-2 was dissolved in 18 liters of fresh water in the presence of 1 kg of molasses to make up a total volume of 20 litters of extended EM solution. Two above ground cement pits/silos with equal dimensions of 2 x 1.5 x 1 m (length, width and height) were prepared per each treatment for T2, T3 and T4. The volumes of the straw mass to be treated at a time was determined taking into account the length of the experimental period, calves' daily intake and live weight of the experimental animals. The walls of the pits were covered with polyethylene sheet and followed by placing, trampling and compacting batch by batch until filled to the pit's capacity. Finally, the pits were sealed with plastic sheet and loaded on top by heavy stones to make it airtight (Figure 2). For all treatment options, wheat straws were left to ferment in the silo for twenty-one days as per the respective recommendations made for each case above.

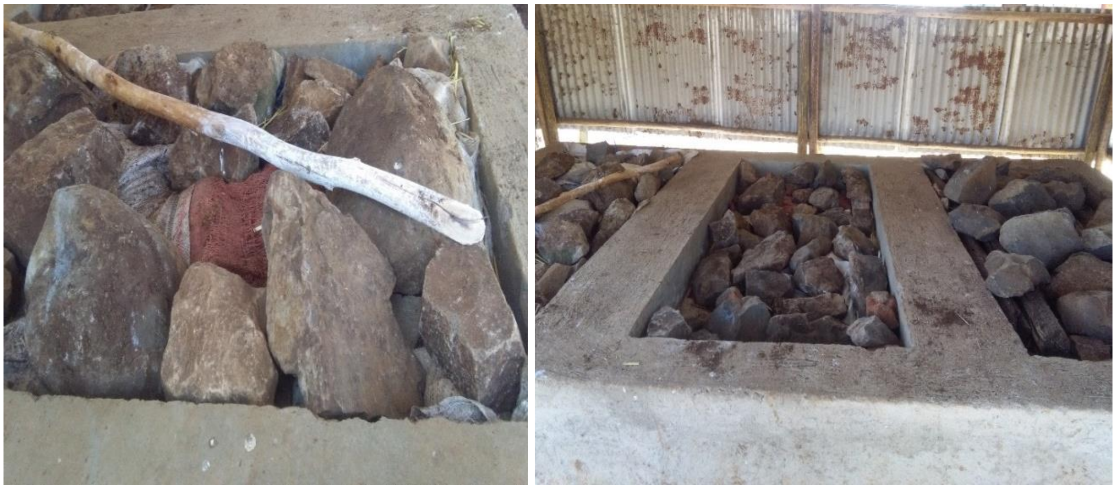

Figure 2: Concrete pits loaded on top by heavy stones

During the actual feeding trial, the daily required amount was taken out of the pit only from an opening in one corner, aerated overnight in case of urea-molasses and urea-lime treated straws to avoid residual ammonia and fed to the animals. The basal diet (treated and untreated wheat straw) was fed *ad libtam* (20%) refusal expected from the previous day's offer while supplemental concentrate diet was fed at the rate of 1.2% live weight of the calves. Concentrate allowance for each calf under each dietary treatment was subjected to revision on a fortnightly basis. Commercial concentrate mixes for growing calves enough to cover the entire experimental period were purchased from local feed processing plant. The purchased concentrate feed contains 16.5% crude protein, 42.6% NDF and 26.2% ADF. Kearl (1982) was referred to formulate the total diet so that the diet could roughly provide 12% CP 8 Mcal; ME/kg feed DM to help the calves achieve 500 g daily growth rates. The calves were individually stall fed in a well-ventilated barn with concrete floor and appropriate drainage slope and gutters. Clean and potable water were available at all times throughout the experimental period. For the laboratory based trial, five representative samples from different batches were taken from the theier respective silos to determine major response variations in feed proximate, detergent and *in vitro* dry matter digestibility fractions existing among the straw samples treated using the various treament options.

3.4 Data Collection Procedures

3.4.1 Chemical composition of feed and feces

Samples of feed offered and refused were taken daily and composited per feed type and per treatment for chemical analysis. Daily collected feces from each animal were weighed in the morning before feeding and 10% representative sub-samples were taken and kept in dip freezer at -20°C. On the last day of the collection period, the composite fecal samples for each animal were thawed, thoroughly mixed and sub-sampled for chemical analysis. DM, total ash and crude protein (CP) were analyzed using the procedure of (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and permanganate lignin was determined following laboratory procedures of (Van Soest and Goering, 1985). *In-vitro* dry matter digestibility (IVDMD) was determined using the two stage *in-vitro* digestibility technique of Tilley and Terry (1963).

3.4.2 Feed DM and nutrient intake

The basal diets were weighed for each animal individually at the rate of 20% refusal from the previous day's offer. Both the basal and supplemental feeds were provided twice per day at 07:30 AM and 04:00 PM. The amount of feed was weighed every morning and refusals were weighted on the next day before the morning feed. Data was recorded on the daily amount of total, supplemental and basal feed consumed by each individual calve and for each treatment under consideration. The difference between feed DM offered and refused was considered as feed DM intake and the same procedures were used to calculate daily calves' nutrients intake.

3.4.3 Apparent dry matter digestibility

Apparent dry matter digestibility of the total diet was determined using the total fecal collection method. The digestibility trial was conducted at the end of the feeding experiment using the same animals and similar dietary treatments. Farm personnel were assigned all around the clock to scoop the feces and wash the concrete floor with high pressure water coming through a plastic hose to avoid urine contamination during fecal collections. Fecal samples were collected for seven consecutive days during which time also daily feed offered and refused for each animal was recorded for the determination of daily feed and nutrient intake. Apparent DM and nutrients digestibility of the total feed were calculated as the difference between nutrients intake and that recovered in feces expressed as a proportion of nutrient intake (Khan *et al*., 2003).

$$\text{DM/Nutrient digestibility (\%)} = \frac{\text{DM/Nutrient intake} - \text{DM/Nutrient in feces}}{\text{DM/Nutrient intake}} \times 100$$

3.4.4 Live weight change and feed conversation ratio

Initial body weight was taken for two consecutive days after overnight fasting of the calves and the mean weight was taken as the initial weight. Subsequently, each animal was weighed fortnightly after once again overnight fasting of the animals and before fresh feed and water was being offered to the animals. Total body weight change was determined as a difference between final weight and initial weight. While daily body weight gain was calculated as an average of the fortnightly live weight changes divided for the same number days the live weight changes have been recorded for each individual calves. The feed conversion ratio of calves was determined. An animal that produces greater body weight with the same feed intake or the same body weight with less feed intake was considered more efficient than its counterparts. Feed intake is important in defining food conversion ratio (FCR). It was calculated as:

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Average daily intake}}{\text{Average daily gain}}$$

3.4.5 Feed cost analysis

Calculation of total feed cost analysis for each calf managed under each dietary treatment was based on comparison of only total feed cost (roughage and concentrate) and straw treatment cost incurred per kilogram straw mass for the three dietary treatments and the cost incurred per kilogram of untreated straw mass for feeding the calves in the control group. The current market price and cost involved for treating a kg straw mass on DM basis is as indicated below. Wheat straw cost =5.6 Birr/kg, concentrate feed =9.4 Birr/kg. Treatment cost (chemicals, labor for chopping and ensiling the straw mass) for the three dietary treatments: - 3.13, 2.75 and 2.95 Birr/kg straw mass of wheat straw treated using urea-molasses, urea-lime and extended effective microbial solution, respectively. Costs that didn't vary over the treatments (fixed costs) were not in general considered in the calculations.

3.5 Statistical Data Analysis

Data were analyzed using the ANOVA procedures of R software version 4.1.0. Mean separations for all the parameters were subjected to Tukey's HSD test at P = 0.05.
The statistical model used for the feeding and digestibility trails was:

$Y_{ij} = \mu + T_i + B_j + \varepsilon_{ij}$; where Y_{ij} = Response variable; μ = over all mean; T_i = treatment effect; B_j = block effect; ε_{ij} = random error.

The statistical model for the lab-based trial was:

$Y_{ji} = \mu + T_i + \varepsilon_{ji}$; where Y_{ij} = Response variable; μ = over all mean; T_i = treatment effect; ε_{ij} = random error

4. RESULTS

4.1 Chemical Composition of Experimental Feeds

The chemical composition of the experimental diets is presented in Table 2. The chemical composition of wheat straw was significantly affected (P<0.001) by the treatments. The dry matter percentage significantly (P<0.001) higher for UWS followed by that of ULTWS, EMTWS and UMTWS. Total ash contents were highly comparable (p<0.001) for UMTWS, ULTWS and EMTWS, and higher than that recorded for untreated wheat straw sample. Crude protein values for UMTWS > ULTWS > UWS > EMTWS (P<0.001). NDF and ADF constituents of UWS and ULTWS were high (P<0.001) compared to that of UMTWS and EMTWS. The IVDMD values were comparable for UMTWS and EMTWS, and significantly (P<0.001) lower for ULTWS as compared to untreated UWS.

Table 2: Chemical composition and IVDMD of Experimental diet

Parameters	**DM%**	**CP**	**Ash**	**NDF**	**ADF**	**ADL**	**IVDMD%**
Concentrate	89	16.5	10.2	42.6	26.2	5.3	68.3
UWS	93.1^{a}	2.94^{c}	10.5^{b}	76.48^{a}	53.39^{a}	6.31^{a}	47.90^{c}
UMTWS	69.8^{d}	6.31^{a}	11.8^{a}	74.98^{b}	51.39^{b}	6.18^{a}	52.35^{a}
ULTWS	75.2^{b}	4.88^{b}	11.5^{a}	76.14^{a}	52.86^{a}	5.75^{b}	50.90^{b}
EMTWS	71.4^{c}	2.76^{d}	11.3^{ab}	53.43^{c}	51.12^{b}	5.64^{b}	53.30^{a}
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[a-d] Means with different superscript letters in the column shows significantly different (P<0.05), WS=Untreated wheat straw, UMTWS=Wheat straw treated with urea-molasses, ULTWS=wheat straw treated with urea-lime, EMTWS= Effective Microorganisms treated wheat straw, NDF= neutral detergent fiber, ADF =Acid detergent fiber, ADL= Acid detergent lignin, IVDMD=In vitro dry matter digestibility

4.2 Feed Dry Matter and Nutrient Intake

Feed and nutrient intake of experimental calves fed on untreated and treated wheat straw-based diets are presented in Table 3. The roughage, total dry matter and organic matter intake values of calves were observed to be high (P<0.001) for ULTWS and EMTWS diets than the UMTWS and UWS diets. Dry matter intake when expressed as percent body weight was not affected by the treatment (P>0.05). On the other hand, the mean CP intake was significantly affected (P<0.001) by urea-molasses and urea-lime treatments. Fiber (NDF and ADF) intake were also affected significantly (P<0.001) by urea-lime treatment, except on EMTWS that had comparable ADF intake. The various wheat straw treatment options with exception that observed for ULTWS based diets didn't produced substantial differences in daily amount of NDF and ADF consumptions compared to calves receiving the control diet.

Table 3: Dry matter and nutrient intake of calves fed untreated/treated wheat straw (Means ±SD).

Intake (kg/d)	**Treatment**				**P-value**
	T1	**T2**	**T3**	**T4**	
Roughage	1.63 ± 0.35^{b}	1.72 ± 0.29^{b}	2.37 ± 0.44^{a}	2.15 ± 0.48^{a}	<0.001
Concentrate	1.40±0.24	1.40±0.30	1.30±0.30	1.40±0.35	NS
Total dry matter	3.02 ± 0.58^{b}	3.10 ± 0.56^{b}	3.70 ± 0.70^{a}	3.50 ± 0.82^{a}	<0.001
Dry matter (%BW)	3.24±0.53	3.36±0.74	3.46±0.76	3.48±0.88	NS
Total organic matter	2.70 ± 0.52^{b}	2.74 ± 0.50^{b}	3.24 ± 0.65^{a}	3.12 ± 0.73^{a}	<0.001
Crude protein	0.28 ± 0.05^{b}	0.35 ± 0.067^{a}	0.34 ± 0.07^{a}	0.29 ± 0.07^{b}	<0.001
NDF	2.31 ± 0.44^{b}	2.34 ± 0.42^{b}	2.78 ± 0.56^{a}	1.88 ± 0.44^{c}	<0.001
ADF	1.60 ± 0.31^{b}	1.59 ± 0.29^{b}	1.94 ± 0.34^{a}	1.79 ± 0.42^{ab}	<0.001

$^{a\text{-}c}$ Means with different superscript letters across the row shows significantly different (P<0.05), NDF= neutral detergent fiber, ADF =Acid detergent fiber, NS =non-significant, d=day, T1=Untreated wheat straw, T2=Urea-molasses treated Wheat, T3=Urea-lime treated wheat straw, T4= Effective Microorganisms treated wheat straw.

4.3 Apparent Dry Matter and Nutrient Digestibility

Apparent dry and organic matter, and nutrient digestibility of experimental calves as affe cted by treatment is presented in Table 4. The DM, OM, CP and ADF apparent digestibili ty was observed to be significantly (P<0.01) higher for straw treated with urea-molasses, urea-lime and activated effective microorganism. NDF apparent digestibility significantly high for urea-molasses and urea-lime treated (P>0.001) straw, and apparent digestibility v alues of NDF for untreated and activated effective microorganism treated samples were at par.

Table 4: Apparent DM and nutrient digestibility of calves fed untreated/treated wheat straw (Means ±SD).

	Treatment				
Parameters	**T1**	**T2**	**T3**	**T4**	**P-value**
DM%	47.4 ± 5.24^{b}	61.1 ± 11.73^{a}	65.1 ± 5.00^{a}	64.6 ± 7.70^{a}	<0.01
OM	51.0 ± 5.34^{b}	63.5 ± 11.22^{ab}	67.3 ± 4.50^{a}	66.5 ± 7.30^{a}	<0.01
CP	40.88 ± 6.40^{b}	60.40 ± 13.50^{a}	57.06 ± 5.82^{a}	55.52 ± 11.25^{a}	<0.01
NDF	60.15 ± 3.63^{b}	71.03 ± 8.01^{a}	73.95 ± 3.27^{a}	59.65 ± 8.73^{b}	<0.001
ADF	54.6 ± 3.20^{b}	64.3 ± 9.90^{a}	68.59 ± 3.81^{a}	66.52 ± 7.55^{a}	<0.01

$^{a\text{-}c}$ Means with different superscript letters across the row shows significantly different (P<0.05), DM =Dry matter, OM =Organic matter, CP =Crude protein, NDF =Neutral detergent fiber, ADF=Acid detergent fiber, T1=Untreated wheat straw, T2=Urea-molasses treated Wheat, T3=Urea-lime treated wheat straw, T4 = Effective Microorganisms treated wheat straw.

4.4 Growth Performance and Feed Conversion Ratio

Growth performance of calves fed treated straw is presented in the Table 5. The value for final body weights significantly (P<0.05) high for urea-lime, effective microorganism and urea-molasses treated straw. Superior live weight changes values were recorded for urea-lime and effective microorganism treated straw (P<0.001). Similarly, ADG of calves was higher for straw treated by urea-lime and effective microorganism (P<0.001). Significantly higher FCR values were recorded for untreated straw followed by that of urea-molasses and effective microorganism treated straw, while the value for urea-lime treated straw being inferior (P<0.01).

Table 5: Growth performance and feed conversion ratio of calves fed wheat straw untreated/treated (Means ±SD).

Parameters	Treatment				P-value
	T1	**T2**	**T3**	**T4**	
IBW (kg)	98.3±16.2	101.5±22.2	97.8±20.9	99.7±24.8	NS
FBW (kg)	$115.5±18.2^{b}$	$125.2±27.7^{ab}$	$133.3±29.8^{a}$	$132.5±33.7^{a}$	<0.05
LWC (kg)	$17.2±4.1^{b}$	$23.7±8.3^{b}$	$35.5±9.2^{a}$	$32.8±9.9^{a}$	<0.001
ADG (g)	$204.3±49.0^{b}$	$281.7±98.9^{b}$	$422.7±109.9^{a}$	$391.0±117^{a}$	<0.001
FCR	$15.1±2.79^{a}$	$12.1±3.9^{ab}$	$8.8±0.78^{b}$	$9.4±1.80^{b}$	<0.01

$^{a\text{-}c}$ Means with different superscript letters across the row shows significantly different (P<0.05), NS= not significant, T1=Untreated wheat straw, T2=Urea-molasses treated Wheat, T3=Urea-lime treated wheat straw, T4= Effective Microorganisms treated wheat straw, IBW=Initial body weight, FBW= Final body weight, LWC=live weight change, ADG=Average daily gains, FCR=Feed conversion Ratio.

4.5 Feed Cost Analysis

The roughage cost, concentrate cost and total feed cost (Birr) as affected by treatments we re presented in Table 6. Roughage cost is significantly high (P<0.001) for urea-lime and e ffective microorganism treated groups followed by the straw treated by urea-molasses, an d the cost of untreated straw was significantly inferior. The cost of concentrate feeds was not significantly (P>0.05) different among treatments. Total feed cost was higher for urea -lime and effective microorganism treated straw (P<0.001) followed by that of urea-molas ses and untreated straw. TFC/WG was superior for untreated straw and the one treated by urea-molasses treated straw (P<0.05), while the values for urea-lime and effective microo rganism treated straw being at par.

Table 6: Experimental feed cost analysis of calves fed treated/untreated wheat straw (Means ±SD).

Parameters	Treatment				P-value
	T1	T2	T3	T4	
Roughage	9.1±1.96^{c}	15.0±2.60^{b}	19.8±3.70^{a}	18.2±4.10^{a}	<0.001
Concentrate	13.0±2.30	13.2±2.90	12.2±2.80	12.8±3.30	NS
TFC (Birr/hd/d)	22.2±4.20^{c}	28.1±5.10^{b}	32.0±6.44^{a}	31.0±7.24^{a}	<0.001
TFC/WG	110.8±19.51^{a}	109.6±35.40^{a}	76.7±6.80^{b}	82.5±15.80^{b}	<0.05

$^{a\text{-}c}$ Means with different superscript letters across the row shows significantly different (P<0.05), NS= not significant, T1=Untreated wheat straw, T2=Urea-molasses treated Wheat, T3=Urea-lime treated wheat straw, T4= Effective Microorganisms treated wheat straw, TFC= total feed cost, WG = weight gain, hd=head, d=day.

5. DISCUSSION

5.1 Chemical Composition of Experimental Feeds

The observed improvement in the DM, CP, NDF, ADF and ADL in urea-molasses treated wheat straw is in agreement with the finding reported for maize stover and rice straw treat ed by urea-molasses (Fitsum, *et al*., 2016; Sheikh *et al.,* 2017; Mudavadi *et al.,* 2020). Mo reover, improvement in the nutritional value by urea-lime treated wheat straw as compare d to untreated wheat straw in the current study can fairly be compared to previous finding conducted on urea-lime treated sesame straw in Ethiopia by Teferi *et al.* (2014) and to the results reported elsewhere by Nguyen *et al*. (2012) and Wanapat *et al.* (2013). Ash conten t was significantly affected by treatment, and this could be justified by the higher mineral concentration in the molasses and quick lime (CaO) used to make up the solution for the respective treatment options. Lime and/or urea-lime inclusions in the treatment of wheat straw has also been reported to have improved CP, reduced cell wall composition and enh anced rumen degradation (Chaudhary, 2000; Can *et al.,* 2004; Millam *et al*., 2017).

The IVDMD of wheat straw in the present study was significantly improved by all the tre atment options used as compared to the untreated straw. In support of the present study, Daniel *et al.* (2016) observed incremental changes in the IVDMD of sorghum stover treat ed by EM and urea solutions. Similarly, the observed IVDMD in the current study is in lin e with that reported by Getu *et al.* (2016), Girma and Alemayehu (2018), Degitu *et al.* (20 20), and Regasa *et al.* (2019) that treatment with EM of cereal straws resulted in substanti al reduction in the straw's cell wall constituents (NDF, ADF and ADL). However, reducti on in CP content observed in the EM treated wheat straw as compared to the untreated str aw in the present study can be speculated to the biochemical change that occurs on the sol uble carbohydrates and protein during fermentation (McDonald *et al*., 2010). In agreeme nt with the current study Yonatan *et al*. (2014) and Regasa *et al.* (2019) reported minor re duction in CP content. Contrary to the present finding Getu *et al.* (2016) and Lemma and Endalew (2017) noted marked improvements in CP contents of the EM treated cereal resi dues. Any variability with findings from previous but related studies could be associated t o straw and variety types, level of chemicals/microbial inoculants used in the respective c ases and environmental factors under which the trials were conducted. In general, all treat ment options used in the current study resulted to tremendous changes on the proximate, d etergent and IVDMD fractions compared to the untreated straw implying the existence of even wider scope of utilization of the various crop residue treatment options under the exi sting socio-economic and farming systems in the country.

5.2 Dry Matter and Nutrient Intake

Positive responses in the mean daily dry matter and nutrient intakes of the calves with the various treatment options in this study is in agreement with the earlier report by Tesfaye (2006) for crossbred calves that were fed on urea treated maize Stover. Likewise, Wanapat *et al.* (2013) reported better intake for dairy cows fed with a basal diet of urea-lime treate d rice straw than urea treated and untreated groups. In line with this again Ajebu *et al.* (20 09) and, Nguyen *et al.* (2012) reported improvements in the dailly average dry matter and nutrient intakes of sheep and buffalo fed with quick lime (calcium oxide) treated wheat an d rice straws than for untreated straws, respectively. Compared to the urea-molasses, urea -lime treatment of wheat straw resulted in higher daily feed intake of the calves. This coul d probably be attributed to the combined effect of urea and lime than urea and molasses in the solutions used to treat the straw (Wanapat *et al.*, 2013).

Treatment of wheat straw with effective microorganism in the current study also remarka bly increased DM and nutrient intake of calves. This result conforms well with that report ed for washara sheep fed on finger millet treated with effective microbial solution (Degitu *et al.*, 2020). In general, the observed improvement in the basal, total feed and nutrient int ake with the treated straw mass, in general, and ULTWS and EMTWS, in particular, from the present study could be associated with the improvement in the feed and nutrient appar ent digestibility and chemical compositions and IVDMD fractions of the treated wheat str aw-based diets. Intake of calves fed untreated but chopped wheat straw-based diet from th e current study need to be appreciated. Havekes *et al*. (2020) also reported as feeding cho pped wheat straw alone at about 30% in dairy cattle diet could result in improved intake, r educe feed selection, greater metabolic health and rumen stability in lactating cows in the absence and/or lack of affordability for one or more of the treatment options used in the current study. The finding from the present study further indicated that either one of the urea-lime and/or effective microbial solution can be used as they are cost effective to improve wheat straw as well as nutrient intake of weaned growing crossbred calves fed on treated wheat straw.

5.3 Apparent Dry Matter and Nutrient Digestibility

In the current study improvement of wheat straw using the different treatment options considerably increased DM and nutrient apparent digestibility of total experimental ration under each dietary treatment compared to that for untreated wheat straw-based ration. This could be linked to increase in proximate detergent and IVDMD fraction of wheat straw caused by the respective treatment options. Dry matter and nutrient digestibility of calves fed on the urea-lime treated wheat straw showed significant difference over the calves receiving the control diet. As is also the case in the present study Millam *et al.* (2017) observed improvement in dry matter and nutrient digestibility of groundnut residue treated with urea-lime solution. Likewise, dry matter and nutrient apparent digestibility of calves fed on the urea-molasses treated wheat straw form the current study can somehow be compared to the result reported earlier by Fitsum *et al*. (2016) for urea-molasses treated maize stover based diet.

Treatment of wheat straw with effective micro-organisms in the current study has been observed to have improved calves’ digestibility of wheat straw as compared to the untreated wheat straw. This also goes in par with that reported earlier by Girma and Alemayehu (2018) and Degitu *et al.* (2020). Comparable feed DM and nutrient digestibility among the treated straw groups indicates that any one of the treatment options can be used under local condition by taking into account local cost and availability of major inputs required for the respective treatment option under consideration.

5.4 Growth Performance and Feed Conversion Ratio

As compared to the control, all treatment options, in general, remarkably improved growth performance of the calves which can directly be related to the improved feed dry matter, nutrient intake and apparent digestibility of the calves in the treated diets. Higher feed conversion ratio recorded for calves in the ULTWS and EMTWS groups in particular might have helped these calves gain more body weight over those receiving the remaining diets. The result obtained from caves fed urea-molasses treated wheat straw (T2) in the present study was comparable with the result of Fikadu (2021) who reported an average daily weight gain of 279.94±3.60 g for crossbred calves aged from weaning to yearling and that maintained on the station’s conventional calves’ diet at Holetta Research Center. However, the average daily gains of calves fed urea-lime (T3) and effective microorganisms treated wheat straw (T4) in the current study were much greater than calves fed this same conventional feed earlier at HARC.

The result from the current study was in agreement with the study of Egbu (2014) and Tesfaye (2006) both of whom have reported significant changes in growth of N’Dama and crossbred calves fed urea treated maize Stover, respectively. Similarly, the average daily gains of calves fed urea-lime treated wheat straw in this study was in par with the study conducted on crossbred heifers fed rice straw treated with a combination of 2% urea and 3% lime and that additionally supplemented with green feed and concentrate (Trach *et al.,* 2001). The average daily gains of calves fed urea-molasses treated wheat straw were, however, lower than that observed by Sarwar *et al.* (2011) for crossbred calves fed wheat straw fermented with cattle manure and urea-molasses. The difference in the average daily gains of calves fed untreated and urea-molasses treated wheat straw from the current study was marginal. This result was in agreement with the result of Elias and Fulpagare (2015) who were unable to find difference in the growth performance of crossbred calves fed on treated and untreated maize stover based diets. The finding for UMTWS based diet from the current study also supports the contention given by Sahoo *et al.* (2004) that feeding of urea-molasses supplemented wheat straw-based diet sustains minimum growth potential in growing animals in addressing future animal productivity.

The caves fed urea-molasses treated wheat straw consumed more dry matter 12.1 to gain a single gram weight. In agreement with current result, Tesfaye (2006) reported 12.2 FCR in study done on crossbred calves fed urea treated maize Stover. The feed conversion ratio (FCR) of the observed results conforms well to the result declared earlier by Trach *et al.* (2001) that reported improved FCR of crossbred calves fed urea-lime treated rice straw supplemented with green feed and concentrate. The maximum difference in FCR observed between calves fed urea-lime treated and untreated group was 6.3 g feed /each g gained. This difference was more than two-fold higher than the 2.9 g feed /each g gained reported by Trach *et al*. (2001) for crossbred calves fed on the urea-lime treated and untreated rice straw-based diets. The contrasting result with this latter but same author may be attributed to the variation in the type of straw and treatment additives used in the respective cases.

5.5 Feed Cost Analysis

There was no significant difference in the daily feed costs recorded for experimental calves that were fed on the ULTWS and EMTWS based diets. Feed cost analysis further indicated that each kg of the live weight gained by the caves fed urea-molasses, urea-lime and effective microorganisms treated wheat straw was achieved with relatively lower daily feed cost than calves maintained on the control diet. This result was in agreement with the report by Tesfaye (2006) which indicated that greater daily body weight gains for calves fed urea treated than untreated maize stover based diets. Similarly, feed cost per kg body weight of calves receiving the ammoniated wheat straw was lower compared to calves on untreated wheat straw (Gao, 2000). The growth performance achieved with urea-lime treated wheat straw-based diet in current study was exceptionally higher due mainly to the higher FCR of the calves. This is in agreement with same finding from a related study by Gao (2000).

6. CONCLUSION AND RECOMMENDATIONS

The present study was conducted on-station using 24 weaned crossbred calves with the objectives to determine the response in the growth performance and economic benefits as measured through feed cost per kg body weight gains of crossbred calves fed on wheat straw treated with urea-molasses, urea-lime and effective micro-organisms. The experiment was conducted in (RCBD) with four dietary treatments and six calves used as a replicate animal. The treatment diets included: - Untreated wheat straw (T1), urea-molasses treated wheat straw (T2), urea-lime treated wheat straw (T3) and effective microorganism treated wheat straw (T4). It can be concluded that the various wheat straw treatment options affected chemical composition and IVDMD of wheat straw. Urea-molasses treatment improved the CP% more than two-fold compared to the untreated straw. On the other hand, the fiber constituents were found to be significantly reduced by effective microorganism treatment. The highest dry matter intake was observed for calves in the T3 group followed by T4, T2 and T1 in that order of importance. Apparent dry matter and nutrient digestibility for the treated wheat straw-based diets was significantly improved compared to the untreated wheat straw-based diet. Daily weight gain of experimental calves was increased by feeding treated wheat straw-based diets in that order of importance: T3 = T4 >T2=T1 with higher FCR still being recorded for calves receiving the treated wheat straw-based diets. The highest total feed cost relative to the live weight gain of calves being recorded for calves receiving the untreated wheat straw diet.

Generally, it could be concluded that treating wheat straw using urea-molasses, urea-lime and EM improved nutritional values, enhanced growth performance cost-effectively when fed to crossbred calves supplemented with concentrate offered at the daily rate equal to 1.2% of the fortnightly live weight changes of experimental calves. However, to draw complete conclusion further research needs to be conducted to identify the optimum level of lime in the urea-lime combinations used for crop residues treatment. Moreover, the same trial has to be conducted on these and other ruminant species found under varying levels of physiological conditions.

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8. APPENDICES

Appendix 1: Analysis of variance table for feed dry matter content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1029.62	343.21	122.68	4.997e-07
Residuals	8	22.38	2.80		

R-Squared	CV	MSE
98	2.2	2.80

Appendix 2: Analysis of variance table for crude protein content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	25.724	8.5747	7872699	2.2e-16
Residuals	8	0.000	0.0000		

R-Squared	CV	MSE
100	0.025	1.089167e-06

Appendix 3: Analysis of variance table for Ash content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	2.8370	0.94568	19.192	0.0005178
Residuals	8	0.3942	0.0493		

R-Squared	CV	MSE
0.88	2.0	0.05

Appendix 4: Analysis of variance table for feed neutral detergent fiber content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1136.03	378.68	4938.7	2.087e-13
Residuals	8	0.61	0.08		

R-Squared	CV	MSE
99	0.4	0.08

Appendix 5: Analysis of variance table for feed acid detergent fiber content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	11.0161	3.672	83.376	2.242e-06
Residuals	8	0.3523	0.044		

R-Squared	CV	MSE
96.9	0.4	0.044

Appendix 6: Analysis of variance table for feed acid detergent lignin content

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	0.96697	0.32232	51.987	1.367e-05
Residuals	8	0.04960	0.00620		

R-Squared	CV	MSE
95	1.32	0.01

Appendix 7: Analysis of variance table for feed In vitro dry matter digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	50.208	16.7361	97.082	1.244e-06
Residuals	8	1.379	0.1724		

R-Squared	CV	Mean sq E
97	0.8	0.17

Appendix 8: Analysis of variance table for initial body weight of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	48.3	16.11	0.4732	0.7055
Block	5	8354.3	1670.87	49.0790	9.087e-09
Residuals	15	510.7	34.04		

R-Squared	CV	MSE
94%	5.9	34.04

Appendix 9: Analysis of variance table for final body weight of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1012.8	337.61	4.183	0.02443
Block	5	14689.0	2937.80	36.399	7.176e-08
Residuals	15	1210.7	80.71		

R-Squared	CV	MSE
93	7.1	80.7

Appendix 10: Analysis of variance table for total weight gains of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1144.83	381.61	13.9727	0.0001287
Block	5	987.33	197.47	0.8769	0.0012543
Residuals	15	409.67	27.31		

R-Squared	CV	MSE
84	19.4	27.31

Appendix 11: Analysis of variance table for average daily gain of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	181998	60666	14.35	0.0001114
Block	5	126535	25307	5.99	0.0030810
Residuals	15	63417	4228		

R-Squared	CV	MSE
83	20.01	4227.8

Appendix 12: Analysis of variance table for total dry matter intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1.7512	0.58375	10.409	0.0005908
Block	5	8.4371	1.68742	30.088	2.603e-07
Residuals	15	0.8413	0.05608		

R-Squared	CV	MSE
92.4	7.1	0.056

Appendix 13: Analysis of variance table for organic matter intake of calves

Source variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1.3167	0.43890	9.9486	0.000737
Block	5	6.6333	1.32665	30.0713	2.613e-07
Residuals	15	0.6618	0.04412		

R-Squared	CV	MSE
92	7.11	0.044

Appendix 14: Analysis of variance table for roughage dry matter intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	2.20333	0.73444	19.271	2.095e-05
Block	5	2.59833	0.51967	13.636	3.951e-05
Residuals	15	0.57167	0.03811		

R-Squared	CV	MSE
89	9.93	0.038

Appendix 15: Analysis of variance table for concentrate dry matter intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	0.03458	0.01153	1.4664	0.2636
Block	5	1.72375	0.034475	43.8551	1.99e-08
Residuals	15	0.11792	0.00786		

R-Squared	CV	MSE
94	6.5	0.008

Appendix 16: Analysis of variance table for feed covariation ratio of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	151.204	50.401	7.8629	0.002196
Block	5	38.783	7.757	1.2101	0.351524

Residuals	15	96.151	6.410		

R-Squared	CV	MSE
66	22.3	6.41

Appendix 17: Analysis of variance table for crude protein intake of calves

Source variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	0.001788	0.0005961	1.7889	0.1924
Block	5	0.075104	0.0150207	45.0747	1.645e-08
Residuals	15	0.004999	0.0003332		

R-Squared	CV	MSE
94	6.2	0.0003

Appendix 18: Analysis of variance table for neutral detergent fiber intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1.1840	0.39468	11.724	0.0003246
Block	5	5.0181	1.00362	29.813	2.768e-07
Residuals	15	0.5050	0.03366		

R-Squared	CV	MSE
92	7.15	0.033

Appendix 19: Analysis of variance table for acid detergent fiber intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	0.66614	0.22205	14.690	9.797e-05
Block	5	2.22830	0.44566	29.483	2.982e-07
Residuals	15	0.22673	0.01512		

R-Squared	CV	MSE
93	7.2	0.015

Appendix 20: Analysis of variance table for percent of body weight intake of calves

Source of variation	DF	Sum Square	Mean square	F value	Pr > F

Treatment	3	0.2199	0.07331	1.6114	0.2286
Block	5	10.1473	2.02947	44.6086	1.768e-08
Residuals	15	0.6824	0.04549		

R-Squared	CV	MSE
93	6.3	0.0454

Appendix 21: Analysis of variance table for feed organic matter digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	822.07	274.023	9.1845	0.00108
Block	5	427.52	85.504	2.8659	0.05193
Residuals	15	447.53	29.835		

R-Squared	CV	MSE
74	8.95	29.8

Appendix 22: Analysis of variance table for feed dry matter digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	980.73	326.91	9.3442	0.0009955
Block	5	473.70	94.74	2.7080	0.0615805
Residuals	15	524.78	34.99		

R-Squared	CV	MSE
73	10.1	35.0

Appendix 23: Analysis of variance table for crude protein digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	1331.90	443.97	5.9275	0.007105
Block	5	804.35	160.87	2.1478	0.115437
Residuals	15	1123.50	74.90		

R-Squared	CV	MSE
65	16.2	74.9

Appendix 24: Analysis of variance table for neutral detergent fiber digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	3349.4	1116.47	11.2475	0.0004011
Block	5	864.0	172.80	1.7408	0.1860399
Residuals	15	1489.0	99.26		

R-Squared	CV	MSE
74	30.1	99.26

Appendix 25: Analysis of variance table for acid detergent fiber digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	830.43	276.810	7.1865	0.003244
Block	5	394.75	78.949	2.0497	0.129329
Residuals	15	577.77	38.518		

R-Squared	CV	MSE
68	10.1	38.5

Appendix 26: Analysis of variance table for acid detergent lignin digestibility

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	619.54	206.513	9.0683	0.001146
Block	5	283.40	56.681	2.4889	0.078395
Residuals	15	341.59	22.773		

R-Squared	CV	MSE
73	6.9	22.8

Appendix 27: Analysis of variance table for roughage feed cost

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	395.43	131.810	47.325	6.976e-08
Block	5	160.43	32.087	11.520	0.0001051
Residuals	15	41.78	2.785		

R-Squared	CV	MSE
93.0	2.8	10.8

Appendix 28: Analysis of variance table for concentrate feed cost

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	3.056	1.0186	1.4664	0.2636
Block	5	152.311	30.46.21	43.8551	1.99e-08
Residuals	15	10.419	0.6946		

R-Squared	CV	MSE
94	6.5	0.70

Appendix 29: Analysis of variance table for total feed cost

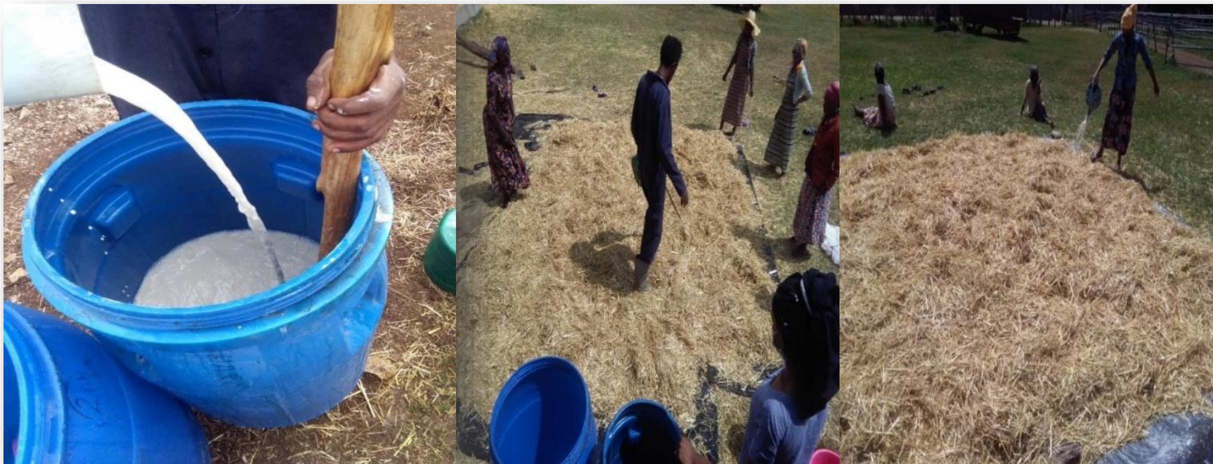
Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	352.59	117.531	26.501	3.039e-06
Block	5	617.26	123.452	27.837	4.374e-07
Residuals	15	66.52	4.435		

R-Squared	CV	MSE
94	7.4	4.43

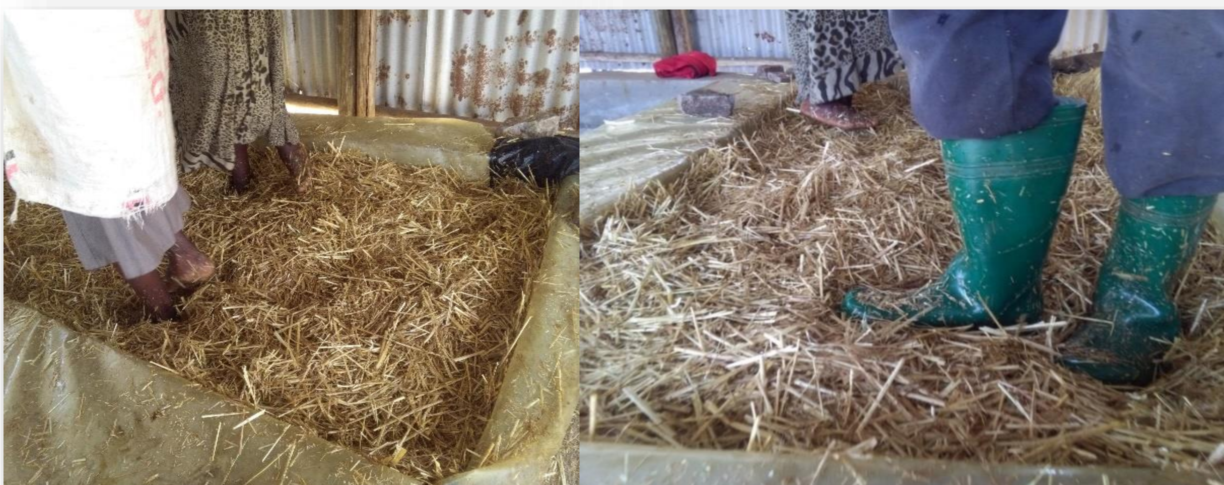
Appendix 30: Analysis of variance table for total feed cost per body weight gains

Source of variation	DF	Sum Square	Mean square	F value	Pr > F
Treatment	3	5722.5	1907.50	4.2514	0.02319
Block	5	2914.9	582.99	1.2993	0.31584
Residuals	15	6730.2	448.68		

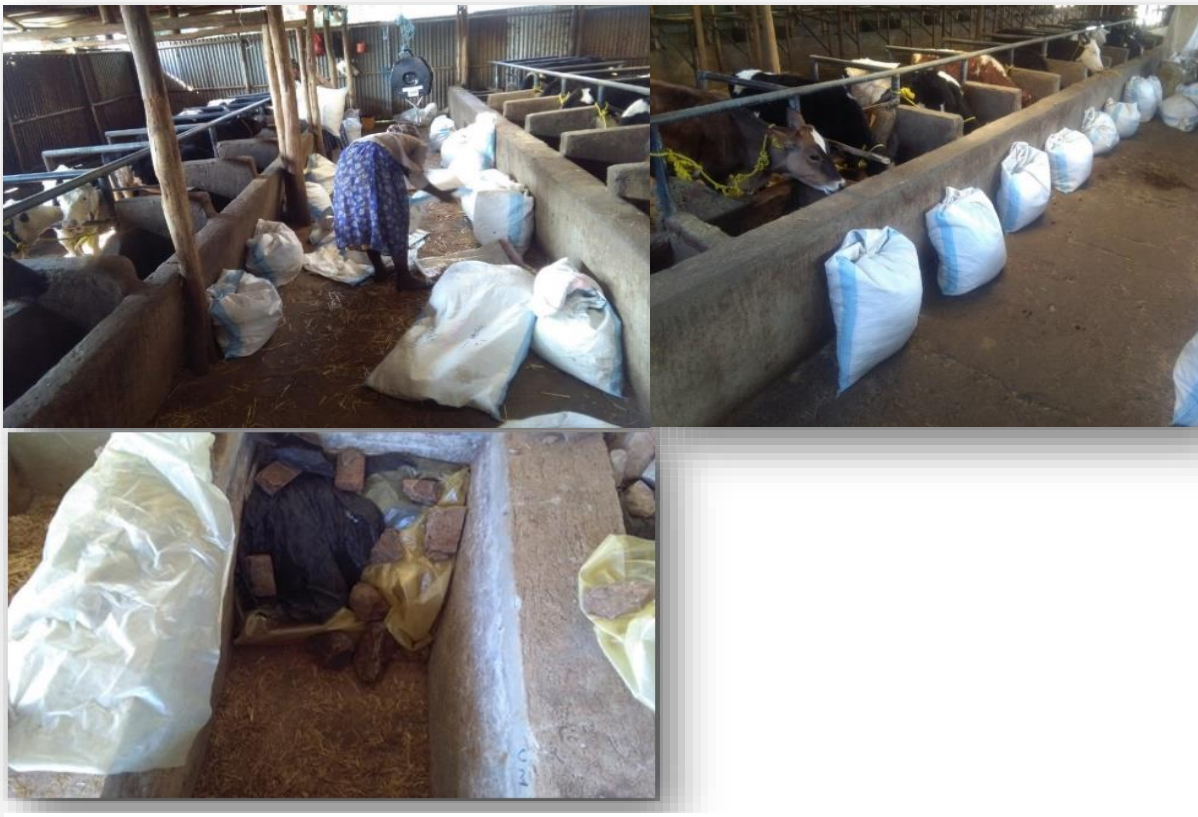
R-Squared	CV	MSE
56	22.3	448.7



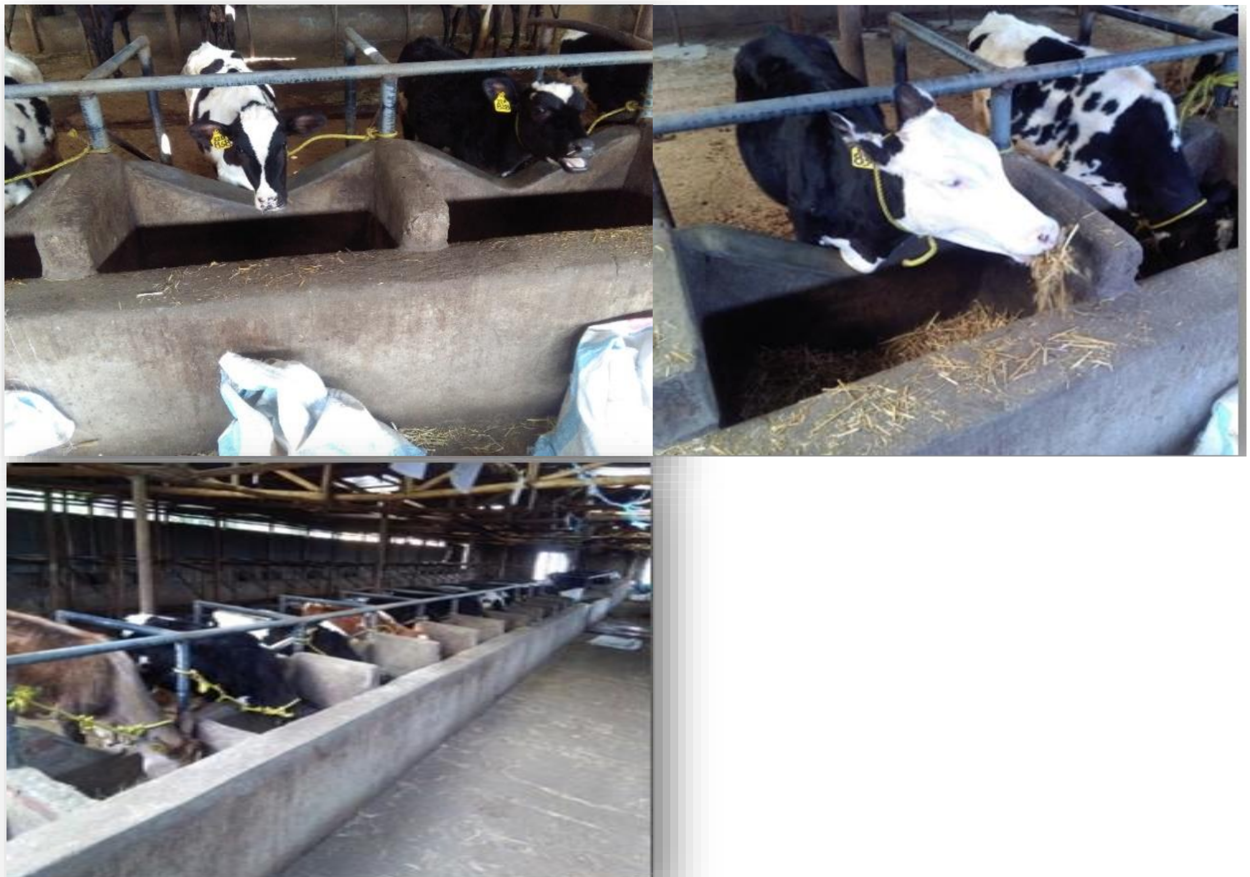
Appendix 31: Urea-lime preparation and spraying on chopped straw



Appendix 33: Trampling of straw



Appendix 35: Feeding out and measuring feed for each animal



Appendix 37: Calves on feeding

Data collection sheet

Type of experiment: Calves feeding Trial

Year 2021

Location: Holetta Agricultural Research center

Date ----------------------------------

Data collection sheet

Animal ID	Trt	Blocks	Feed offers			Feed Refusal		BW	Health status
			Concentrate		Roughage	Concentrate	Roughage		
			AM	PM					

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ADDIS ABABA UNIVERSITY
College of Veterinary Medicine
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Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/25/06/13/2021

Name of Applicant: **Kedir Mohammed (BSc in animal production, MSc fellow)**

Address: Department of Animal Production Studies, College of Veterinary Medicine and Agriculture, Addis Ababa University

Title of the project: *Effects of feeding Urea-molasses, Urea-lime and activated effective micro-organism treated wheat straw basal diets on feed intake and growth performance of weaned (Holstein-Friesian x Borana) female calves at Holeta Research Center, Ethiopia*

Date of application: **December, 2020**

Nature of the project: **Mildly invasive**
Target animal species: **Cattle**
Number of animals involved: **24**
Study area: **Holeta Research Center, Ethiopia**

Minutes No. and date of review: **VM/ERC/06/13/021, 28/03/2021**

The above indicated research project is acceptable from ethical perspective, relevance, originality and technical competence points of view. Hence the project is ethically sound to be executed provided that:

1. All procedures and conditions stipulated in the proposal are respected, minor comments are corrected and any deviation or changes be reported to the committee
2. The project activities be open for occasional supervision by the committee when deemed necessary

Getachew Terefe (DVM, PhD, Professor of Vet. Parasitology)
Chairman

Signature

The Federal Democratic Republic of Ethiopia
Addis Ababa University College of Veterinary Medicine and Agriculture

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