Omo International Journal of Sciences

Volume 6 Issue 2 Year 2023

ISSN: 2520-4882 (Print), 2709-4596 (Online)

Novelty and Relevance

Arba Minch, Ethiopia

Omo International Journal of Sciences Volume 6 Issue 2 Year 2023

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Omo International Journal of Sciences
An official Journal of the Arba Minch University, Ethiopia

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Research Article

Participatory demonstration of *Pennisetum pedicelluatum* and elephant grass *(Pennisetum purpureum)* strip as biological soil and water conservation measures for erosion control

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Abstract

On three beneficiary farmer fields, prescaling up and participatory demonstration of biological soil conservation techniques using Desho (*Pennisetum pedicelluatum*) and Elephant grass (*Pennisetum purpureum*) were carried out in 2019/2020 in comparison with control (no grass) activities. Assessing the role of biological conservation techniques in reducing soil erosion and farmers' opinions of these techniques was the primary goal. A total of 132 m2 demonstration plots were used to collect and analyze the experimental data. Elephant grasses (134 tons/ha) and desho (61.1 tons/ha) differed significantly ($P < 0.05$) in the second year. Elephant grass provided an average soil loss of 6.6 tons/ha/yr-1, desho grass produced an average of 10.9 tons/ha/yr-1, and control provided an average of 13.4 tons/ha/yr.The elephant grass plots showed the least amount of nutrient loss, while the control plots showe d the greatest amount.When compared to Desho grass, elephant grass has a higher potential to control soil l oss due to its robust root system and to rebound quickly, even in the event of a severe drought.Furthermore , because elephant grass grows quickly and has the largest freshweight biomass of any grass, farmers gave it more consideration in their assessments of grass strips than they did Desho grass.In order to improve acc eptability and spread of the technology in dry land areas with a 5% slope for managing soil and nutrient los ses, it is best to scale up elephant grass on a bigger scale. The highest nutrient loss was observed on the control plots and the least on the elephant grass plots. Based on the study results, elephant grass has a high potential to control soil loss through a strong root system and recovery immediately, even under severe drought conditions, compared with Desho grass. Additionally, farmers' evaluations of grass strips showed a higher attention to elephant grass than Desho grass due to the fast-growing nature of the grass and their highest fresh-weight biomass. Finally, it is better to scale up elephant grass on a larger scale to enhance acceptance and diffusion of the technology in dry land areas on a slope of 5% for controlling soil and nutrient losses.

Keywords: Biological soil and water conservation; Desho grass; Soil and nutrient loss

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https://doi.org/10.59122/14439nk

Received July 7, 2023; Accepted October 3, 2023; Published December, 2023

1. Introduction

Soil erosion is one of the most damaging and wide-spread occurrences and is recognized as a key issue for heartwarming food security. Of the total areas affected by soil degradation, global water erosion occupies 56% (Oldman et al., 1991) and affects 80% of agricultural land (Angima et al., 2003). Global assessment of human-influenced soil degradation informed us that about 36% of farmlands are degraded at rates of 5–6 million per ha per year (Scherr, 1999). The problem is severe in developing countries (like Africa and Asia); most of the lands in Africa are susceptible to soil and environmental degradation (Wim & El-Hadji, 2002).

Erosion convinced soil degradation to aggravate the problems of low agricultural productivity, food insecurity, and rural poverty in Ethiopia (Smith, 2010). In the highlands of Ethiopia above 1500 m.s.l., erosion removes over 1.5 billion tons of top soil fertile soil annually (Taddese, 2001). The rate of soil loss in Ethiopia was put in severity levels of very high (>100 t/ha/yr), high (50–100 t/ha/yr), moderate (10–50 t/ha/yr), low (1–10 t/ha/yr), and no erosion (<1 t/ha/yr) (Hurni, 1983).

In light of these problems, efforts to regulate the impacts of land degradation on soil productivity have been under way in various parts of the country. Major types of conservation methods introduced were structural, and of these, the most common were fanayajuu and soil bunds (Belay, 1992). For instance, soil bunds reduced soil loss by 39 percent in Tigray (Greegziabher et al., 2008) and by 50 percent in Anjeni (Herweg and Ludi, 1999). Besides; soil bunds promote rainwater infiltration (Crtichley et al., 1994).

As WOCAT frame work focuses on locally tried and tested techniques, the public and private partners use Desho grass across the escarpment in densely populated highlands for a sustainable land management program (Smith, 2010). This grass had been used as a grass strip to protect crop land from soil erosion and degradation in the highlands of Ethiopia (Welle et al., 2006; Yacob et al., 2015), to rehabilitate degraded land (Smith, 2010), and to improve grazing land and livestock feeding (Welle et al., 2006; Danano, 2007).

As compared to other grasses (*P. purpureum*, *Vetveria zizanoides*) used for land management practices in Ethiopia, In the study area, limited information is available on farmers' effects of grass strips on soil conservation. This study aimed to assess' farmers' perceptions of biological conservation and to demonstrate the contribution of desho and elephant grass to controlling soil erosion.

2. Materials and Methods

2.1 Description of the study area

The study was conducted on Denba Gofa woreda, which is one of seven *woreda* in the Gofa zone, located 505 km from Addis Ababa and 275 km south-west of Hawassa. The study area lies at 6025'.208 N latitude and 37^{0}02'.698" longitude. It has an altitude of 1200m. Based on the 2007 population census of the Federal democratic republic of Ethiopia, the total population of the population of which 40,335 were male and 40,823 40,823 female (Federal Democratic Republic of Ethiopia Population Census Commission, 2008).

The *woreda* is bound by Zala woreda in the south and south-east, Uba Debretsehay Woreda in the south, Oyda and Geze Gofa in the west and north-west, the Omo River in the north, and Kucha *Woreda* in the east. The area that accounts for 75% (more than ¾) of the total land area is lowland, characterized by irregularities and deficiency of rainfall in the district, and it is relatively sparsely populated because of the prevalence of tropical diseases like malaria.

Based on the data from the Rural and Agricultural Office of the *woreda*, the land area measures 97,468.44 hectares, of which 48% is currently cultivated, 27% is employed for grazing, and 25% is under bush, shrubs, and forests. It has an optimal rainfall distribution that is favorable to a variety of crops: teff, maize, barely, pea, highland sorghum, avocado, bean, orange, chickpea, cabbage, enset, pineapple, onion, and potato. Coffee and korerima are the main cash crops.

2.2 Implementation procedure

A field participatory demonstration work was examined on the effects of biological soil and water conservation methods on soil loss and maize production during cropping seasons in 2011 and 2012 E.C. at Denba Gofa Woreda with a plot size of 6x22 $^{m2.}$ The biological soil conservation measures used were Desho (*P. pedicelluatum*), Elephant (*P. pupureum*), and Control (without grass strip) on three farmers' fields (slope of 5). Planting of maize variety 540 was done during the main rainy season, from the beginning of March up to the end of April each season, at a spacing of 75cm by 25 cm. The spacing between the grass splitting of desho grass (30 cm) and elephant grass (40 cm).

2.3 Data collection methods

The collected data for the trial was grass strip biomass, soil moisture content, soil loss, soil nutrients, and farmer preferences.

2.3.1 Determining soil loss

The experimental field was built in February of 2011 on three farmers land on a slope of 5%. Each runoff field (catch pit) had a length of 5 m, a width of 1 m, and a 0.5m depth made from plastic sheet. The plots were set up, and the soil collected in the catch pit was measured after the end of the rain fall.

The plots were bounded by a corrugated iron sheet, buried to a depth of 20cm and protruding 10cm above the ground to prevent runoff water from outside the plots from entering the plots and that from runoff plots from flowing out unmonitored.

2.3.2 Grass biomass

The green biomass grass yield harvest of both Desho and Elephant was carried out after three months of planting, while the other harvest was done at a 15-day interval for elephant grass and a one-month interval for Desho grass.

2.3.3 Determining soil moisture content under treatments

Measuring soil moisture was conducted at three periods (initial, development, and mid-stage) to evaluate the amount of soil water during dry periods. A composite soil sample taken by an auger was used for soil sampling from a depth of 0–20 cm, and 20–40 cm was used as "x" around the field to collect soil from various places on the field. From each of the two depths, collect sub-samples of the auger sample and mix well in a plastic bucket. The weight of the wet soil samples was measured and put in an oven at 105°C for 24 hours, and then the weight of the dry samples was measured.

The amount of soil water stored (%) in each 0.4-meter incremental depth was determined gravimetrically. It was then converted to water depth (mm) by multiplying by the specific bulk density values measured by the core sampler methods as described by Blake (1965).

2.3.4 Farmer's preference and perception

Data on farmers' observations towards the grass strip were collected using focus group discussions. Farmers were asked to list standards they would like to consider in their preference. Criteria defined after focus group discussion included reducing soil loss, drought resistance, animal preference, harvesting frequency, easy establishment, and fast growth.

Farmers were asked to prioritize the grass strip by giving scores based on each criterion: 3 for excellent, 2 for very good, 1 for good, and 0 for not good.

2.4 Data analysis

One-way ANOVA in SPSS version 20 is used to examine farmers' opinions and preferences about plants in connection to biological water and soil conservation variables. Nevertheless, the randomized block design model was used in the analysis of the experimental data. The least significant difference procedure was followed by the mean separation. The block effects were determined to be insignificant ($P > 0.05$).

3. Results and Discussion

3.1 Farmers perceptions towards grass strips for soil and water conservation

Results for the farmers' scores of the grass strip practices presented in Table 1. The values reflected the farmers' perceived degree of importance of each grass practice based on their evaluation criteria. Farmers gave scores based on their multipurpose nature. Accordingly, farmers gave the first rank to elephant grass except for palatability and the second rank to desho grass. The discussion with farmers showed that elephant grass is fast-growing, easy to establish, drought-resistant, reduces soil erosion, and has a higher harvesting frequency than Desho grass. The elephant grass was found to be extremely superior to the Desho grass in terms of different criteria, but the palatability of elephant grass decreases as its maturity increases, and accordingly, the farmer's Desho grass has a highly palatable nature. However, it was not easily established because the study area was dry and also because the harvesting frequency was low compared with elephant grass. However, elephant grass within a month is harvested 2-3 times and recovers rapidly even in dry situations**.**

Table 1. Farmer's perception and preference of desho and elephant grass strips based on evaluation criteria

Criteria for comparison	Preference ranking	
	Desho grass	Elephant grass
Reduce soil loss	1	3
Drought resistance	1	3
Animal preference	3	1
Harvesting frequency	1	2
Easy establish	1	3
Fast growing	1	2
Mean	0.8	1.4
Rank	2nd	1st

Score 3= Excellent, 2=Very good, 1=Good, 0=Not good

Desho grass is used as a year-round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010), mainly grown on small home plots used for livestock

fodder fodder, soil conservation practices, and sold for income generation as small business opportunity, mostly for high land Ethiopian farmers (IPMS, 2005; Shiferaw *et al.*, 2011; Leta *et al.*, 2013). It is a very palatable species to cattle and sheep (Ecocrop, 2010) and is mainly grown on small home plots used for livestock fodder and soil conservation practices.

Biological practices are quick and cheaper than physical structures, compassionate to rehabilitation lands, protect land from further degradation, and stabilize physical structures for a long period of time (Abinet, 2011; Terefe, 2011).

3.2 Grass biomass means under the treatments

As shown in the above Table 2, only elephant grass fresh biomass data was taken because elephant grass survived and established earlier than desho grass. This could be due to the fast-growing nature of the grass. However, due to their inability to withstand the drought conditions in the research regions, nearly 50% of the planted seedlings did not survive in the first year. My personal experience has shown that highland areas are typically ideal for desho grass. According to Smith (2010) who reported that desho grass is naturally spreading across the escarpment of the highlands and used for multiple purposes.

Table 2. Mean performance of grass strip biomass

Plants	Biomass yield, ton/ha	
	2011 year	2012 year
Elephant grass	56	61.1[a]
Desho grass	-	13[b]
LSd (%)	-	4.4
CV (%)		41

In year two, there were significant ($P < 0.05$) differences between desho (61.1 tons/ha) and elephant grasses (134 tons/ha). The highest fresh weight biomass data were produced from elephant grasses due to their rapid growth rate. Elephant grass has higher annual biomass productivity than desho. According to Karlsson and Vasil (1985), elephant grass is the fastest-growing plant in the world. A study in Florida reported a dry biomass yield of 45 dry ha−1year−1 (Woodard and Sollenberger, 2008).

Elephant grass has for long been an important forage crop in the tropics because of its high yields and nutrient value. The biomass yields of approximately 80 dry t ha−1year−1 (Vicente-Chandler *et al.,* 1959) in the tropics and exceeding 45 dry t ha−1year−1 (Prine *et al.*, 1988) at ~30°N latitude (Gainesville, Florida, USA) have been reported.

3.3 Mean of soil loss

As we can see in Table 3, there was no significant (P > 0.5) difference between the treatments in 2011. This is due to the vegetal zed structures helping reduce the effects of soil erosion because the grass strips were not successfully established and covered the soil in the first year. Vegetative barriers such as grass can retard runoff and capture sediment from concentrated flow (Meyer & Turner, 1994). Thus, as a vegetative barrier develops, it decreases water speeds and forms a broad, identical vegetative surface for the uptake of nutrients.

Vegetative barriers have the potential to not only reduce erosion but also increase vegetated filter strips' uptake of nutrients. In year two, there was a significant (P < 0.05) difference between the elephant grass (8.633 ton/ha) compared with the control (24.3 ton/ha), but no significant difference (P > 0.05) between the elephant grass (8.66 ton/ha) compared with the desho grass (18.14 ton/ha) and the control (24.3 ton/ha) compared with the desho grass (18.14 ton/ha) treatments. The results show that elephant grass has great potential to control soil loss through a strong root system and recover quickly even under severe drought conditions, compared with desho grass.

Table 3. Soil loss means under the different treatments

Treatments	Soil loss ton/ha/yr-1	
	2011 year	2012 year
Desho grass	15.24[a]	18.14[ab]
Elephant grass	12.75[a]	8.633[b]
Control	19.165[a]	24.3[a]
Lsd (%)	17	12.7
Cv (%)	50	32.9

Similarly, elephant grass has been used as mulch (a 25-cm layer) for weed control, water storage, and to reduce soil losses on slopes (Adekalu *et al*., 2007; Francis, 2004). Elephant grass grows a vigorous root system that may help inhibit river bank erosion. Planted as borders, elephant grass makes barriers and provides effective windbreaks for crops and houses. It is used for erosion control and forage production in alley-cropping systems of agroforestry (Magcale-Macandog *et al*., 1998).

The soil loss was high in control (without a grass strip) compared with desho grass and elephant grass. Soil erosion and loss of organic matter associated with conventional tillage practices were high, which left the soil bare and unprotected in times of heavy rain and wind (Chivenge *et al*., 2007).

3.4 Nutrient loss

The different nutrient losses and soil erosion affect the ecosystem via nutrient deposition and sedimentation. As we can see from the above table 4, the control (without a grass strip) is the most sensitive to fertility erosion, with the highest amounts of N, P, and OC losses (25.6; 8.3; 293.12 in the first year and 28; 9.08; 320.6 kg ha-1, respectively). The detached top layers are highly concentrated in soil nutrients (Thomas et al., 1993), and this strongly compromises agricultural activities due to acute nutrient depletion in eroded soils. Under high rates of runoff and sediment, nutrient dilution is high (Sidibé, 2005), while elephant grass had the lowest values (16.8; 4.56; and in the 2nd year, 4.56; 194 kg ha-1), all three nutrient elements. The results of the study show that efforts should be geared toward implementing physical soil conservation measures alongside fertility-improving methods. Soil conservation is fundamentally a matter of determining the correct form of land use and management (Sanders, 2002).

Table 4. The nutrient loss under the treatments (kg/ha/yr)

Treatments	2011 year various parameter loss				2012 year various parameter loss			
	Total soil	TN	AP	OC	Total soil	TN	AP	OC
Elephant grass	8400	16.8	4.56	194	4800	9.6	2.6	110.88
Control	12800	25.6	8.3	293.12	14000	28	9.08	320.6
Desho grass	12000	24	7.5	292.8	9800	19.6	6.12	239.12

Soil loss can be reduced by appropriate crop management, which includes cover cropping, multiple cropping, and high-density planting (Junge *et al*., 2008). The highest nutrient loss was observed on the control plots and the least on the elephant grass plots, which received external inputs, especially inorganic fertilizer treatments. The relatively lower amounts of nutrient loss observed under elephant grass strip-treated plots could be explained by the least soil loss under this treatment. With respect to the higher amount of N, P, and OC lost under control (without a grass strip), there were no vegetative barriers with increased soil sediment transport. This study agreed that under high rates of runoff and sediment, nutrient dilution is high, and the total amounts of nutrient loss were higher on the untreated plots than the treated plots (Sidibé, 2005).

3.5 Mean of maize yield and yield components

In both years, there was no significant ($P > 0.05$) difference between the treatments in all parameters (Table 5). This result shows that the effect of soil and water conservation structures is observed after some years of the structure being built. This finding agrees with the studies conducted by Herweg and Ludi (1999) who reported that comparisons made between local

cultivation and SWC structures at experimental sites in Ethiopia showed that soil loss is reduced significantly for the majority of SWC treatments, such as level bunds, but production rarely increases as a result of SWC in three to five years of age.

Table 5. Mean performance of maize growth parameters under treatments

Treatments	2011 year			2012 year		
	PH (m)	DMB, (t/ha^{-1} $year^{-1}$)	Grass yield, (t/ha^{-1} $year^{-1}$)	PH (m)	DMB (t/ha^{-1} $year^{-1}$)	GY
Elephant grass	2.43	7.1	6	1.94	6.9	5.4
Desho grass	2.45	8.3	5.575	2	8	5
Control	2.372	8	5.75	2.1	7.6	5.6
Lsd (%)	NS	NS	NS	NS	NS	NS
Cv (%)	5	10	8	6	20	17

M=Metere, GY=Grass yield, PH= Plant height

Wolka *et al*. (2013) reported that 79.3% of the interviewed farmers perceived the increment in yield after 2 years of SWC structures (the soil bund and stone bund) were put in place. Herweg and Ludi (1999) indicated a 4-50% decline in yield during the first 3–5 years after the construction of SWC measures.

4. Conclusion

A participatory demonstration and pre-scaling up of Desho grass and Elephant works was accompanied in Denba Gofa woreda with the objectives of the Desho and Elephant grasses contribution to controlling soil erosion and farmers perceptions of these measures. The maize data collected were plant height, biomass matter, and grain yield, but there was no great difference between all the treatments. However, soil loss ton per hectare was higher in control plots and low in elephant and desho grass plots. Soil erosion is a threat to the decline of agricultural productivity. Areas with a slope greater than 5% are more prone to soil erosion that decreases soil fertility. Therefore, it is critical to use and apply soil conservation measures in the areas to prevent soil loss from erosion. Based on the study results, elephant grass has a great potential to control soil loss through a vigorous root system and recover rapidly even under severe drought conditions compared with Desho grass. Besides, farmers' evaluations of grass strips showed a higher interest in elephant grass than Desho grass due to the fast-growing nature of the grass and its highest fresh-weight biomass. Additionally, the cut grass can be used as livestock fodder. In this regard, elephant grass was recommended in our study area and in similar agroecologies for future demonstration and scaling up for soil loss control under a slope of 5%.

Hence, there is a need to disseminate the results of the present study to end users, even though further research should be carried out to support the recommendation.

Acknowledgment

The authors gratefully credit the Arba Minch Agricultural Research Center (AMARC) for sponsoring this research work. The Natural Resources Research Program team of Areka Agricultural Research Center is highly regarded for their proper coordination with the AMRC's activity implementation.

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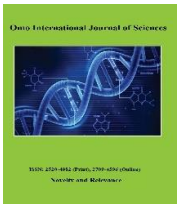

Research Article

Knowledge of antenatal exercise and its associated factors among pregnant women in Arba Minch town, Southern Ethiopia

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Abstract

Antenatal exercise reduces many health-related risks in pregnant women and their fetuses. Adequate knowledge regarding antenatal exercise is vital to practice. However, knowledge of antenatal exercise has not been studied yet in the study area. Therefore, this study aimed to assess knowledge of antenatal exercise and its associated factors among pregnant women in Arba Minch town. Community based cross-sectional study design was conducted. Data were collected by using structured questionnaire from 422 pregnant women selected by simple random sampling technique. Sixteen questions with expected responses of "yes" or "no" were applied to examine knowledge. Descriptive statistics like mean, standard deviation, frequencies, and proportions were computed. In multivariable logistic-regression, AOR with 95% confidence intervals were computed. The significance level was declared at p-value < 0.05. Overall, 46% (95% CI, 41%-51%) of pregnant women had adequate knowledge of antenatal exercise. High school educational level [AOR= 2.45, (95%CI1.04-5.77)], monthly income < 1,347 Ethiopian birr [AOR=0.55,(95%CI 0.33-0.92)], unemployment [AOR=0.33,(95%CI 0.14-0.77)], gravida one [AOR=3.15,(95%CI 1.39-7.14)], gravida two to three [AOR=3.28,(95%CI 1.61-6.69)], four to three months of pregnancy [AOR=0.58, (95%CI 0.38-0.90)] and age < 25 years [AOR= 0.49, (95%CI 0.30-0.79)] were significantly associated with knowledge of antenatal exercise. Knowledge towards antenatal exercise in this setting found to be inadequate. Educational levels, income level, occupation status, gravidity, months of pregnancy and age were factors associated with antenatal exercise. Hence, interventions targeting to improve the income and employment status of pregnant women are recommended.

Keywords: Antenatal exercise; Arba Minch; Knowledge; Pregnant women

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https://doi.org/10.59122/134A31D

Received: 18 July 2023; Accepted: October 8, 2023; Published: December, 2023

1. Introduction

Physical activity is a bodily movement produced by the contraction of skeletal muscles in all stages of life while, exercise is a structured, planned and repetitive movement produced by skeletal muscles (Sharon, 2017). Exercise is a safe and effective way to gain many physical and mental health benefits including maintaining and improving cardiorespiratory fitness, reducing the risk of obesity and associated comorbidities, and resulting in greater longevity (Ribeiro and Milanez, 2011).

Appropriate antenatal exercise has proved to be beneficial to many expectant women, though how much and what kind of exercises varies from person to person and its regular participation of exercise has become an important component of a healthy lifestyle, so antenatal exercise has become a fundamental aspect of women's lives and an important constituent of antenatal care (AM, 2005; Lee *et al*., 2012; Pasanen *et a*l., 2017). Regular exercise is promoted for its overall health benefits. Modern popular culture has embraced the concept of a "fit pregnancy." Scientific findings support the contention that regular exercise during pregnancy incurs little risk and is beneficial, in terms of both mental and physical health (Nascimento *et a*l., 2014).

Studies show that low to moderate impact exercise regime for pregnant mothers performed for about 30 minutes on most days of the week and gradually progressed over a period of time can be followed to improve overall fitness. These exercises include aerobic exercises such as aerobics, swimming, cycling, walking, dancing; core stability, pelvic floor exercises, breathing exercises, postural education and back care (ACOG, 2017). Foot and leg exercises and pelvic tilting can be performed in sitting or half-lying positions, whereas trans versus and pelvic floor exercises can be carried out in any position (EJ, 2005).

Scientific literature shows that, in most cases, exercise is safe for both the mother and fetus during pregnancy and supports the recommendation of initiating continued specific exercise postures can help the pregnant woman to adapt to the physical changes in her body during childbearing in most pregnancies (ACOG, 2017). So American College of Obstetrics and Gynecology (ACOG) recommended that pregnant women can exercise moderately for 30 minutes on most days of the week. Following these recommendations, irrespective of the pregnant woman's physical fitness level, exercise should be low-impact, moderate- intensity, and regular (ACOG, 2017).

For healthy pregnant and postpartum women, at least 150 minutes per week a moderate intensity of aerobic exercise is recommended. Pregnant women who are regularly engaging in vigorous-intensity aerobic activity (i.e., the equivalent of running or jogging) or who are highly active can continue physical activity during pregnancy and their health care provider should better counsel how and when physical exercise will be done over time (Garland, 2017).

Numerous health benefits of antenatal exercise during pregnancy were documented such as the reduced risk of excessive gestational weight gain and conditions such as gestational diabetes, preeclampsia, preterm birth, varicose veins, deep vein thrombosis, and reduced length of labor and decrease delivery complications (Evenson et al., 2014). Psychological benefits of physical activity during pregnancy include reduced fatigue, stress, anxiety, and depression, as well as improved well-being (Evenson et al., 2014).

Furthermore, Antenatal exercise improves the functioning of the fetal and neonatal cardiac autonomic nervous system, normalizes birth weights, and reduces adiposity at birth and in early childhood (May et al., 2010). Additionally, babies born seem to be calmer, are leaner, more intelligent with improved neurological and mental development and their children had significantly higher scores on oral language and general intelligence tests (May et al., 2010).

Although antenatal exercise has a good health impact on pregnant women and their children, studies showed that there is inadequate knowledge of pregnant women towards antenatal exercise. In Saudi Arabia only 69.5% were knowledgeable (al Rahi, Al-Khaldi, Al-Awwad, Ahmed, & Al-Thubaiti, 2018). In Brazil 65.6% (Ribeiro and Milanez, 2011), in Sri lanka Colombo,72.7% were not knowledgeable (Herath et al., 2016), in Zambia 74% of pregnant women had inadequate knowledge (Nkhata, Munalula-Nkandu, & Shula), in Nigeria and Kenya majority of pregnant women had inadequate knowledge about antenatal exercises (Edinah et al., 2018; Chidozie E Mbada et al., 2014).

Globally, thousands of pregnant women suffer different problems and lose their lives daily due to non-involvement in exercise during pregnancy and other preventable, immeasurable pregnancy related complications (Al Rahi et al., 2018). Lack of physical activity in the general population and lack of antenatal exercise were taken as the leading risk factors for death estimating 3.2 million deaths worldwide and the fourth leading risk factor for early mortality worldwide (ACOG, 2017). It was reported that lack of antenatal exercise increased the prevalence of chronic diseases such as cardiovascular disease, type 2 diabetes, osteoporosis and cancer and their risk factors such as raised blood pressure, raised blood sugar and overweight

(Ainsworth et al., 2011) while practicing appropriate antenatal exercise decreases the risk of developing gestational diabetes mellitus, pre- eclampsia, caesarean section rate, reduced symptoms from low back pain and improved mental state (ACOG, 2017). The Worldwide maternal mortality ratio (MMR) is 216 per 100000 live births. Sub-Saharan Africa has a very high MMR 546, (WHO, 2015). Ethiopia is one of the sub-Saharan countries with a high maternal mortality ratio of 412 per 100000 lives (ICF, 2016).

Understanding the existing knowledge about antenatal exercises among pregnant women is valuable for designing an educational intervention to promote antenatal exercise. However, the knowledge status of pregnant women in Arba Minch town has not been studied. Hence this study was designed to assess the knowledge of antenatal exercise and associated factors among pregnant women in Arba Minch town, Southern Ethiopia.

2. Materials and Methods

2.1. Study design, period and setting

The community-based cross-sectional study design was conducted from December 1st to 30th, 2019 GC in Arba Minch town, Southern Ethiopia. Arba Minch town is located 454 Km to the South of Addis Ababa (capital city of Ethiopia) and about 280 Km from the regional city Hawassa. According to the 2007 census, the total population of the town was 74,879, of whom 39,208 are men and 35,671 women (Census, 2007). A total of 23.5% were found to be reproductive age group, among these, 4,084 women are currently pregnant. The numbers of health institutions in Arba Minch town are 1 governmental general hospital, 3 Health centers, 33 private clinics and 13 drug stores.

Populations

The sources populations were all pregnant women in Arba Minch town. All pregnant women who lived in Arba Minch town for at least six months were included. Pregnant women who had medical or obstetric complications and serious psychological conditions that could have an impact on the information were excluded.

2.2 Sample size determination and sampling Techniques

The sample size was determined by using single population proportion formula through Open Epi, Version 3, open-source considering the following assumptions: knowledgeable about antenatal exercise to be 50%, 95% confidence interval of certainty (alpha = 0.05), 5% marginal error, 10% non-response rate. The final sample size was determined as 422. There are four sub-cities in the town, which are divided into 11 Kebeles (small administrative unit of Ethiopia). The

sample size was allocated to all Kebeles proportional to their number of pregnant women sizes. Each pregnant woman was selected by computer generated number simple random sampling technique using a family folder sampling frame.

2.3 Study variables

Knowledge of antenatal exercise was a dependent variable, whereas socio-demographic characteristics like age, occupation, religion, monthly income, educational status, employment and marital status, obstetric characteristics like gravidity, gestational ages, parity, number of children, history of miscarriage, and information source were independent variables.

2.4 Operation definitions

Antenatal exercise is an appropriate and safe type of exercise which is planned and repetitively done by pregnant women to gain the benefits. These exercises are low-impact, moderate-intensity exercise such as walking, stationary cycling, water aerobics, stretching, yoga modified and swimming, pelvic floor exercise, relaxation or breathing exercise while high-impact forms of exercise such as strength training and running should not be performed (ACOG, 2017). Knowledge of antenatal exercise was measured by asking sixteen questions about the benefit and contraindication of antenatal exercise with categorical responses of “yes” and “no” with an item score of “1”, and “0” respectively. Then, the sum was computed and those who responded correctly for the mean and above value were considered as they had adequate knowledge and those who scored less than the mean value was labeled as they had inadequate knowledge about antenatal exercise.

2.5 Data collection instrument and data quality control

Data were collected using a pre-tested structured questionnaire by face-to-face interview which was divided into four parts. Socio-demographic data, Obstetrical histories, Source of antenatal exercise and knowledge of antenatal exercise. The questionnaire was designed in English from literatures on related topics (Mbada et al., 2014; Nkhata et al., 2015) and based on ACOG recommendations. The questionnaire was reviewed by experts and its contents were validated. The reliability test result of Crombach’s alpha was 0.921. Finally, the questionnaire was translated to Amharic for better understanding by data collectors and interviewees. A total of eight data collectors of 4 diploma nurses and 4 diploma midwives were involved in data collection and two supervisors. Before actual data collection, pretest was done on 5% women using the Amharic translated questions to check the clarity, to evaluate the tool, to determine

whether there is any need to do any modification. This was done at Mirab Abaya outside the main study area. Training was given to data collectors and a supervisor before the beginning of actual data collection. The supervisor closely followed the data collection process. The completed questioners from the data collectors were checked for completeness and consistency on daily bases.

2.6 Data analysis

The collected data was coded and entered into Epi Data version 4.6 then exported to SPSS version 25 for analysis. Descriptive statistics like frequencies, percentages, mean, standard deviations were computed. Binary logistic regression model was also used. Variables with a p value ≤ 0.25 level in the bivariate analysis were entered into multivariable analysis.in addition; the context and findings of previous studies were considered in the identification of candidate variables for multiple variable logistic- regressions to adjust for possible confounding variables. Adjusted odds ratio (AOR) with 95% confidence interval (CI) were used to measure the strength of associations and p value of < 0.05 was used to determine the presence of association with the outcome variable. Hosmer and Lemeshow model fitness test was used to assess model fitness and it was a good fit.

3. Results

3.1. Socio-demographic characteristics of study participants

Of the 422 women interviewed, 410 (97.20%) provided complete information on antenatal exercise and were used in these analyses. The mean ± SD (standard deviation) age of the participants was 25.82 ±5.16 years. The majority of women 233(56.80%) were within the age category of ≥ 25 years. More than half of the study participants 231 (56.30%) were protestant Christians. A majority of the participants 390 (95.10%) were married. Most women 176 (42.90%) attended up to primary schools while around 30% of their husbands attended their education in university or college. Concerning occupation 335 (81.70%) of the women were none employed. The mean monthly income of the study participants was 1,347 Ethiopian Birr (ETB). More than half 263 (64.10%) of the respondents belong to the income level of ≥1,347 Ethiopia (Table 1).

3.2. Obstetric characteristics of the respondents

The majority of the participants were multigravida 272 (66.30%). Nearly half (46.60%) of them had 1-2 number of living children while more than 90% of the women had no history of miscarriage. Forty-six percent of the women were within four to six months pregnant followed

by seven to nine months of pregnancy. Half of the pregnant women commenced their antenatal care and visited the health institution 1-2 times (Table 2).

Table 1. Socio-demographic characteristics of pregnant women in Arba Minch town, Southern Ethiopia,2020 (n=410)

Variables	Categories	Frequency (n)	Percentage (%)
Age	< 25	177	43.20
	≥ 25	233	56.80
Religion	Orthodox	137	33.40
	Protestant	231	56.30
	Catholic	10	2.40
	Muslim	32	7.80
Marital status	Married	390	95.10
	Divorced	13	3.20
	Widowed	7	1.70
Woman educational Status	Unable to read and write	36	8.80
	Non-formal education	24	5.90
	Primary school (1-8grades)	176	42.90
	High school (9-12 grades)	88	21.50
	College/University	86	20.90
Husband educational status	Unable to read and write	13	3.20
	Non-formal education	52	12.70
	Primary school(1-8grade)	107	26.10
	High school(9-12 grades)	115	28.00
	College/university	123	30.00
	Employed	75	18.30
Occupation	Non employed	335	81.70
Income (ETB)	(Mean income)	1347	
	< 1347	147	35.90
	≥ 1347	263	64.10

Approximately a quarter of the study respondents 29.3% revealed that family/friends were the commonest source of information. From total respondents, 233(56.83%) of the pregnant women reported that antenatal exercise reduces the risk of back pain (Table 3).

3.3 Pregnant women's knowledge about antenatal exercise.

The majority, 219(53.40%) of the pregnant women responded that excessive weight can be prevented by antenatal exercise. About 235(57.30%) of pregnant women reported that antenatal exercise increases energy and stamina. A total of 217(52.90%) women indicated that antenatal exercise helps to cope with labor and delivery pain. Regarding the contraindication of antenatal exercise, a total of 199(48.53%) pregnant women reported vaginal bleeding as contraindication for antenatal exercise (Table 4). The mean score value of pregnant women's

knowledge about antenatal exercise was 7.99 out of 16. Among all participants, only 190 (46.34%) scored above the mean value and had adequate knowledge about the antenatal exercise.

Table 2. Obstetrical characteristics of pregnant women in Arba Minch town, Southern Ethiopia, 2020 (n=410)

Characteristics	Gravidity	Frequency (n)	Percent (%)
Parity	Primi-gravida	138	33.70
	Multigravida	272	66.30
	Nulliparous	136	33.20
	Prim-parous	135	32.90
	Multiparous	140	34.10
Number of alive child they have	No child	135	32.90
	1-2	191	46.60
	>2	83	20.20
History of miscarriage	Yes	39	9.50
	No	371	90.50
Gestational age	<4 months	34	8.30
	4-6 months	189	46.10
	7-9 months	187	45.60
ANC follow up	Not started	102	24.90
	1-2	208	50.70
	Three and above	100	24.40

Table 3. Source of information about antenatal exercise among pregnant women in Arba Minch town, Southern Ethiopia, 2020

Source	Frequency	Percent (%)
Health care provider	97	23.7%
Health extension worker health	99	24.1%
Family/friends	120	29.3%
Mass media Tv	43	10.5%
Internet	38	9.3%
Books	13	3.2%
Total	410	100.0

3.4 Factors associated with knowledge towards antenatal exercise

Bi-variable and multi-variable logistic regression analyses were done to assess the association between the selected variables and knowledge towards antenatal exercise. During adjusted binary logistic regression analysis, six explanatory variables were statistically significant associated. These were women's educational level, income level, occupation, gravidity, pregnancy months and age of the women (Table 5).

Table 4. Knowledge result of antenatal exercise of pregnant women in Arba Minch town, Southern Ethiopia, 2020 (n=410)

Benefits and contraindiction of antenatal exercise	Response	Frequency	Percent
Reduces risk of back pain	Yes	233	56.83
	No	197	43.70
Prevents excessive weight gain	Yes	219	53.40
	No	191	46.60
Increases energy and stamina	Yes	235	57.30
	No	175	42.70
Help cope with labor and delivery pain	Yes	217	52.90
	No	193	47.10
Can reduces risk of DM	Yes	143	34.90
	No	267	65.10
Can decrease high blood pressure during pregnancy	Yes	196	47.80
	No	214	52.20
Helps more rapid postnatal recovery	Yes	190	46.30
	No	220	53.70
Can prevents antenatal and postnatal depression	Yes	213	52.00
	No	197	48.00
Benefits general health and development of the baby	Yes	241	58.80
	No	169	42.00
Contraindications			
Vaginal bleeding	Yes	199	48.50
	No	211	51.50
Uterine contractions	Yes	185	45.10
	No	225	55.90
Chest pain	Yes	196	47.80
	No	214	52.20
Difficulty of breathing	Yes	205	50.00
	No	205	50.00
Premature labour	Yes	201	49.00
	No	209	51.00
Poorly controlled type 1 Diabetic	Yes	179	43.70
	No	231	56.30
Dizziness	Yes	227	55.40
	No	183	44.60

Pregnant women who had high school education were 2.451 times more likely to be knowledgeable about antenatal exercise compared to those who had graduated from college/university and above level [AOR= 2.451, (95%CI 1.039-5.778)]. Those non-employed pregnant women were 67% less knowledgeable about antenatal exercise compared to those who were employed [AOR=0.330, (95%CI 0.141-0.770)]. The pregnant women having a monthly income level less than 1,347 Ethiopian birr (ETB) were 45.10% less knowledgeable about

antenatal exercise, compared to those who had a monthly income of ≥ 1,347 ETB [AOR= 0.549, (95% CI 0.326-0.925)].

Table 5. Bi-variable and multi-variable analysis of factors associated with knowledge towards antenatal exercise in Arba Minch town, Southern Ethiopia, 2020 (n=419)

Variables	Categories	AK	IAK	COR (95% CI)	AOR (95% CI)	P-value
Women educational status	Unable to read and write	6	30	0.241(0.091,.638)	0.381(0.118,1.23)	0.108
	Non-formal education	7	17	0.496(0.187,1.31)	0.971(0.283,3.33)	0.962
	Primary school	39	49	0.959(0.528,1.74)	0.524(0.220,1.25)	0.146
	High school	99	77	1.549(0.922,2.60)	2.451(1.039,5.77)	0.041*
	College/University and above	39	47	1	1	
Occupation	Non-employed	150	185	0.709(0.429,1.17)	0.330(0.141,0.77)	0.010*
	Employed	40	35	1	1	
Monthly Income (ETB)	< 1,347	133	130	0.706(0.469,1.0)	0.549(0.326,0.92)	0.024*
	>= 1,347	87	60	1	1	
Gravidity	One times	60	78	2.000(1.009,3.96)	3.147(1.386,7.14)	
	2-3	115	103	2.903(1.512,5.57)	3.281(1.608,6.69)	0.001*
	more than 3	15	39	1	1	
Pregnancy	< 4 months	13	21	0.539(0.255,1.13)	0.531(.233,1.207)	0.131
Month	4-6 months	77	112	0.598(0.398,0.90)	0.584(0.377,0.90)	0.016*
	7-9 months	100	87	1	1	
Age (in years)	< 25	71	106	0.642(0.432,0.95)	0.488(0.298,0.79)	0.004*

AK: Adequate knowledge, IAK: Inadequate knowledge, CI: Confidence interval, COR: crude odds ratio, AOR: adjusted odds ratio, *statistically significant (p <0.05), '1' reference category.

Those women who were prim-gravida and two to three gravida were 3.147 and 3.281 times more likely to be knowledgeable about antenatal exercise than those women who had above three pregnancies [AOR=3.147, (95% CI 1.386 - 7.147)] and [AOR=3.281, (95%CI 1.608,6.695)] respectively. Pregnant women having four to six months of pregnancy were 41.60% less knowledgeable about antenatal exercise than those pregnant women who had seven to nine months [AOR= 0.584, (95%CI0.377-0.905)]. The pregnant women with the age less than 25 years were 51.20% less knowledgeable about antenatal exercise compared to those whose age is more than 25 years [AOR=0.488, (95%CI0.298, 0.798)].

4. Discussion

In this study, 46% (95%CI 41%-51%) of respondents had adequate knowledge about antenatal exercise. This finding is in line with studies done in Colombo sri Lankan, India and Nigeria (Herath et al., 2016; Chidozie Emmanuel Mbada et al., 2015; Sujindra et al., 2015). However, the finding of this study is lower than studies done in Saudi Arabia and Brazil (Al Rahi et al., 2018; Ribeiro & Milanez, 2011). This might be due to socio-demographic and the absence of Ethiopian antenatal exercise guideline. The study conducted in South Africa showed that women were willing to follow a set of guidelines with supervision to be involved in exercise and it could be due to a positive influence of education and society on the awareness of pregnant women (Au, 2017). However, the finding of this study is higher than a study conducted in Zambia. This discrepancy might be due to factors like differences in educational level, modernization, and other socio-demographic characteristics and difference in accessing information.

Women with high school educational level were more likely to have adequate knowledge to antenatal exercise compared to higher level. These findings are similar to results reported from a study conducted in Zambia (Ribeiro and Milanez, 2011; Sujindra et al., 2015). This may be due to those women were more concerned to the advice given to them about antenatal exercise. Those women having gravidity of one and two or three were more likely to have the knowledge to antenatal exercise. This is in agreement with a study conducted in Zambia. This may be due to the women with the subsequent pregnancies are gaining knowledge of antenatal exercise from earlier pregnancies. Pregnant women with four to six pregnancy months were less likely to have adequate knowledge than those women with seven to nine months. This may be due to as the months of pregnancy increases the antenatal visit increases; this gives the chance for women to get more information about antenatal exercise. Income influences the knowledge of antenatal exercises of women. Those women with higher income were more likely to have adequate knowledge of antenatal exercise when compared with women having low income. This might be due to they can afford the source of information including televisions and other smartphones which may easily link them with social media. The study also showed that occupation influences knowledge of antenatal exercise. Those none employed women were less likely to have adequate knowledge of antenatal exercises compared with employed ones.

This finding was similar to a study conducted in Sri Lankan (Wijesiriwardana and Gunawardena, 2016). This may be due to employed women can access different information

about antenatal exercise from a variety of sources, from the work place and colleagues. And also, the more employed occupation status, the more income level. This study also revealed that, those women whose age was less than 25 years was less likely to have adequate knowledge of antenatal exercise when compared with women having age greater than 25 years. This may be due to when the age increases the women get more pregnancies, have more exposure to many antenatal visits and get more informed.

5. Conclusions

In this study the knowledge of antenatal exercise was inadequate. Educational status, income level, occupation, gravidity, months of pregnancy and age were identified as statistically significant factors associated with knowledge of antenatal exercise. Therefore, interventions targeting to improve the income and employment status of pregnant women by giving special consideration for those less than 25 years old and further qualitative study are recommended.

Conflict of Interest

The author (s) did not disclose any potential conflicts of interest

Acknowledgement

The authors thank Arba Minch University's College of Medicine and Health Sciences for funding and the pregnant women of Arba Minch for providing the data. We would also like to thank the data collectors and the supervisor for completing their tasks.

Ethical approval and consent to participate

The ethical clearance board of Arba Minch University, College of Medicine and Health Sciences ethically approved all the study methods and protocols and responded with a letter reference number IRB/129/12 on the date of 14/11/2019. Informed consent was taken from pregnant women before data collection.

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Research Article

On-farm monitoring of feed effects on milk yield and composition in crossbred dairy cows at Gidole town, Ethiopia

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Abstract

The study was conducted at Gidole town to evaluate the impact of three feeding practices (low, medium, and better-off) on milk composition and yield in Holstein Friesian crossbred dairy (HFCD) cows at the farm level across three lactation stages (early, mid, and late). In the study area, challenges and opportunities for dairy production were thoroughly assessed. Data were collected from 12 systematically selected households (HHs), representing the three feeding groups (poor, medium, and better-off), shortly after cows gave birth. During early lactation, three feeding households had daily milk yields (DMYs) of 3.61± 0.23, 8.25± 0.69, and 9.47± 0.88, respectively. The DMY was 3.64± 0.75, 7.81± 0.87, and 9.37± 0.71 amid lactation. Across all lactation stages, the feeding groups exhibited significant differences in DMY, fat content, protein levels, and lactose composition ($P < 0.05$). The cows' diets directly influenced these variations. Given the reported differences in dairy cow performance among HHs, optimal practices would be disseminated by extension workers. Lack of land, high feed prices, and low productivity were identified as important constraints in the study area, whereas boosting milk demand, revenue, and knowledge through extension services were studied as potential options for milk production.

Keywords: Feeding practices; Holstein Friesian; Milk composition; Milk yield

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https://doi.org/10.59122/13439gmv

Received August 14, 2023; Accepted October 10, 2023; Published December 30, 2023

1. Introduction

With at least 600 million people raising livestock for food, cash income, risk management, and asset accumulation, the development of small-scale livestock enterprises could be a critical component of efforts to eradicate extreme poverty and hunger, particularly in rural areas (Hemme and Otte, 2010). Milk production and composition of dairy cows at the farm level are influenced by a variety of external and internal conditions. External factors such as heat stress, season, and humidity (Lambertz et al., 2014) and internal factors such as parity, stage of

lactation, udder health, and metabolic status (Tančin et al., 2007; Penev et al., 2014) are common factors that influence dairy cow milk production and composition. According to Tančin *et al*. (2020), the majority of these factors are under experimental conditions, but conditions at the farm level are frequently different due to management practices, even if the breeding conditions are the same.

In smallholder dairy cow production, feeds and feeding practices are most likely to influence milk yield and composition. Smallholder dairy cow herds are fed on-farm-grown fodder, crop residues, forages obtained from outside sources, and commercial dairy meal. Depending on the herd's location, pastoral herds are fed shrubs, dry grasses in rangelands, or Euphorbia tirucalli (Noor et al., 2013). Nutritional or dietary influences have a strong influence on fat concentration and milk protein concentration (Looper, 2012).

Feed scarcity in both quantity and quality dimensions is the major bottleneck for the promotion of the livestock sub-sector in Ethiopia. There is marked seasonality in the quantity and quality of available feed resources due to various environmental determinants such as drought and frost, (Jimma et al., 2016) and low management and conservation techniques. According to Tegegne *et al*. (2013), agro-industrial by-products such as bran, middling, oil seed cakes, and molasses are fed as supplements to crossbred dairy cows in urban and peri-urban areas.

Dairy production in Ethiopia is predicted to increase rapidly in response to the fast-growing demand for livestock products resulting from the increasing human population, especially in urban areas, and rising consumer income, provided that appropriate interventions are made along the dairy value chain (Haile, 2009). The increasing demand for livestock products; particularly for milk and milk by-products has far-reaching implications for human well-being, socio-economics, land use, the environment and animal health. To meet the future demand, production of milk, including milk production per lactating cow would need to be increased significantly if the available feed resources are to be sufficient especially in terms of DM, CP and ME. Moreover, unbalanced feeding could lead to the excess feeding of some nutrients whilst others remain deficient. This not only reduces productivity and increases costs per kg product but also affects various physiological functions including long-term animal health, fertility and productivity (Yisehak and Janssens, 2014).

The research approach included two systems-based monitoring programs (on-farm and farmlet monitoring programs) in the southeast Queensland region of northern Australia was

showed a significant effect of the feeding system on true protein concentration and yield (Barber, 2007). The amount of concentrate fed and DIM were the main factors affecting milk protein concentration within feeding systems, true protein and casein concentration were significantly increased by the fiber and starch-based diet, with starch increasing true protein concentration by 0.08% units/kg starch fed (Barber, 2007). That study concluded that dietary non-fiber carbohydrate content over the range of 35 to 40%, is the main factor affecting milk protein concentration. Increasing the ME intake of dairy cows with starch-based concentrates will increase milk protein and casein concentration. The type of feeding system influenced the level of milk protein and the amount of seasonal variation seen, with feeding systems that provide a higher plane of nutrition and a more even supply of nutrients having higher true protein concentrations and less seasonal variation respectively (Barber, 2007). Therefore, it is important to closely consider how feed and feeding practices affect the productivity of dairy cows. This study investigated the impact of farmer feeding practices on milk yield and composition of Holstein Friesian crossbred dairy cows at Gidole town in south Ethiopia to suggest effective management strategies for the smallholder dairy business.

2. Materials and Methods

2.1. Descriptions of the study area

This study was conducted in the Derashe special district at Gidole town at the on-farm level. The overall goal of the study was to develop management strategies based on existing practices in the smallholder dairy sector.

2.2. Sample size and sampling technique

At the start of the study, 60 households at Gidole town were systematically identified and registered as having a Holstein Friesian (HF) crossbred dairy cow. Parity, blood level (50-75%), and body condition were determined in 12 HF cows with similar lactation stages. This was further subdivided into three groups based on the cow's feeding system. At the farm level, the feeding system identified was low, with households feeding dairy cows mostly crop residues, *enset*, and 4.5 liter of *atella* per day. The feed offered to the cow in this category was approximately 4 kg on a feed basis, excluding the *atella* and improved forage was rarely supplemented to the cow. Cows in the second category had a good feeding system, which included crop residues, *enset*, hay, 6 liters of *atella* per day, and salt. The total amount of feed offered, excluding *atella*, was approximately 5 kg. In the category of good feed management, the

cow was given the optimal amount of improved forage. Better-off feeding methods were the third category of management practices for lactating cows. Crop residues, enhanced forages, crop aftermath grazing, green forages, *enset*, agro-industrial byproducts (like molasses), 8 liter of *atella* per day, and salt were all incorporated in the feeding scheme of better-off households. In the better-off category, the cow consumed an average of 7 kg of feed daily excluding *atella*.

2.3. Method of data collection

Beginning with the early lactation period in the household, milk yield data was recorded for 210 days in each feeding system, 70 days for early lactation, 70 days for mid-lactation, and 70 days for late lactation. Similarly, 50 mL composite samples of raw milk from each feeding practice were collected in sterile bottles during the early, mid, and late lactation stages, stored in ice boxes, and transported to Arba Minch University's dairy lab for analysis of milk fat, protein, lactose, total solid not fat, and pH. Three times, samples were collected from the farm and examined at the dairy lab. The study examined factors affecting dairy production in the area, including land availability, credit, skilled workers, and marketing opportunities.

2.4. Data analysis

Using a significance level test set at $P < 0.05$ means and standard errors (SE) were calculated to examine the impact of feeding techniques on milk yield and milk composition. SPSS (Statistical Package for the Social Sciences) 20 for Windows was used to conduct statistical analysis (SPSS Inc., Chicago, USA).

3. Results and Discussion

3.1 Milk yield and milk composition analysis

3.1.1 Early lactation

Table 1 shows the influence of feed and feeding practices on the milk yield and composition of an HF crossbred dairy cow during early lactation. During early lactation, a crossbred dairy cow in the low nutrition management group produced an average daily milk yield (DMY) of 3.61 ± 0.23 liter. The average DMY in a good feeding management category was 8.25 ± 0.69 liter, while the better-off feed management category was 9.47 ± 0.88 liter. During early lactation, DMY varied significantly ($P < 0.01$) depending on household feeding practices. The variability in milk yield seen in dairy cows was mostly attributed to family nutrition, feeding, and management variables.

In households with varying levels of feed management—low, medium, and better-off—the average fat percentage during early lactation in crossbred cows exhibited distinct differences. Specifically, it was 3.03± 0.77, 3.42 ±0.34, and 3.76± 0.64, respectively in poor, good and better-off feeding practices. Notable variation ($P < 0.01$) among family feeding practices. Similarly, the average crude protein content (%) in dairy cow feed management categories during early lactation showed significant differences (Table 1).

It's worth noting that changes in rumen fermentation or fat supplementation, as outlined by the National Research Council (NRC, 1988), can impact the primary precursors of milk fat. These include acetic and butyric acids produced from rumen fermentation, as well as long-chain fatty acids from dietary sources and endogenous pathways. Additionally, Tanin *et al*. (2020) highlighted that milk production and components are influenced by factors such as season, parity, stage of lactation, and somatic cell count.

Table 1. Early lactation milk yield and composition (Mean±SE) of crossbred dairy cows in different feed management practices in the Gidole town

Feed management category	Mean ± SE in early lactation					
	Daily milk yield (liter)	Fat %	Lactose content %	Solid not fat %	Protein content %	pH
Low	3.61±0.23^{c}	3.03±0.77^{c}	4.01±0.47^{a}	6.98 ±0.87^{a}	2.62±0.31^{c}	6.63±0.07^{a}
Medium	8.25±0.69^{b}	3.42±0.34^{b}	3.91±0.49^{a}	7.21±0.74^{a}	3.02±0.17^{b}	6.69±0.10^{a}
Better-off	9.47±0.88^{a}	3.76±0.64^{a}	4.01±0.23^{a}	7.17±0.40^{a}	3.14±0.12^{a}	6.67±0.09^{a}
P- value	< 0.01	0.01	0.08	0.69	< 0.01	0.28

^{abc} means in the column with the same superscript are not significantly different ($P < 0.05$).

3.1.2 Mid-lactation

The influence of feed management practices on milk yield and composition in HF crossbred dairy cows during mid-lactation is presented in Table 2. The average DMY (liter) for cows under feed management categories were 3.64 ±0.751, 7.81± 0.87, and 9.37 ±0.71 for low, medium and better-off, respectively. Significant variation was observed among the three households in average DMY based on feeding practices of dairy cows ($P < 0.01$). This variation highlights the importance of tailored feeding strategies for dairy cows based on their specific conditions.

A previous study revealed significant elements that influence milk composition (Barber, 2007). Dietary non-fiber carbohydrates (NFC) content played a crucial role in determining milk protein and casein levels. Specifically, it affected the proportion of β-casein within the casein fraction. Several farm-level factors influenced milk composition. Whey protein and urea concentrations are affected by dietary acid detergent fiber (ADF) content, temperature-humidity

index (THI), radiation, and maximum temperature. Dietary ADF concentration, THI, radiation, and maximum temperature all impact the proportions of αS- and κ-casein fractions. The amount of concentrate fed and Days in Milk (DIM) are important factors in determining milk protein content across different feeding regimes. In general, knowing and optimizing feed management procedures is critical for increasing milk yield and preserving optimum milk composition in crossbred dairy cows.

The feeding system, particularly the form of management (known as "farmlet"), has a significant impact on milk protein concentration and overall productivity. A study by Barber (2007) at the farm level revealed that different feeding systems significantly influenced milk protein levels. Specifically, feeding systems with a higher plane of nutrition resulted in higher real protein concentrations, but systems with a more consistent supply of nutrients showed less seasonal volatility in milk protein content. Additionally, a higher body condition score at calving positively impacted milk protein concentration, especially during the early to mid-lactation period.

Beyond diet and dairy cow health, several other factors influence crossbred dairy cows. Milk production is influenced by the number of lactation periods and the season of calving. Dairy farm management strategies and technology have an impact on overall milk yield, as do temperature, humidity, and radiation. The slope of the lactation function, which takes into account both milk supply and overall yield, needs to be carefully analyzed.

Jentsch *et al*. (2001) found that different feeding system management methods have a substantial impact on mid-lactation cows. Novak *et al*. (2009) found that early lactation cows are less influenced. In general, understanding and optimizing feeding systems is critical for maintaining milk quality and increasing production in dairy farming.

Table 2. Mid-lactation milk yield and composition (Mean±SE) of crossbred dairy cow in different feed management practices at the Gidole town

Feed management category	Mean ± SE in mid-lactation					
	Daily milk yield (liter)	Fat %	Lactose content %	Solid not fat %	Protein content %	pH
Low	3.64±0.75^{c}	3.17± 0.73^{c}	4.34±0.29^{a}	7.85±0.55^{a}	2.86±0.23^{c}	6.63±0.02^{a}
Medium	7.81±0.87^{b}	3.21±0.22^{b}	4.35±0.22^{a}	7.74±0.24^{a}	3.10±0.16^{b}	6.69±0.03^{a}
Better-off	9.37±0.71^{a}	5.01±0.66^{a}	4.29±0.34^{a}	7.22±0.41^{a}	3.21±0.15^{a}	6.67±0.02^{a}
P –value	<0.01	<0.01	0.88	0.58	<0.01	0.28

$^{a\,b\,c}$ means in the column with the same superscript are not significantly different (P < 0.05).

3.1.3 Late lactation

The influence of household feed management practices on milk yield and composition of HF crossbred dairy cows during the late lactation period is indicated in Table 3. Under different household feed management categories, the average DMY (liter) for crossbred cows was 2.01± 0.24, 3.03± 0.41, and 3.63± 0.39, respectively, which was significant (P< 0.01). The fat and protein content in milk was also significantly affected (P < 0.01). Fat content is particularly sensitive to dietary changes. According to Looper (2012), changing the diet can affect fat levels by roughly 3.0 percentage points, although other milk constituents such as lactose and minerals do not respond reliably to dietary changes. These findings highlight the significance of tailored feed management strategies in optimizing milk yield and maintaining desirable milk composition in late-lactation crossbred dairy cows.

Table 3. Late lactation milk yield and composition (Mean ± SE) of crossbred dairy cows in different feed management practices at the Gidole town

Feed management category	Mean ± SE in late lactation					
	Daily milk yield (liter)	Fat %	Lactose content %	Solid not fat %	Protein content of %	pH
Low	2.01±0.24^{c}	2.85±0.48^{c}	4.36±0.44^{a}	8.53±0.53^{a}	3.11± 0.19^{c}	6.48±0.12^{a}
Medium	3.03±0.41^{b}	3.26 ±0.38^{b}	4.61±0.22^{a}	8.06± 0.26^{b}	3.25±0.16^{b}	6.15±0.15^{a}
Better-off	3.63±0.39^{a}	4.20 ±0.53^{a}	4.32±0.28^{a}	7.62±0.35^{c}	3.29±0.12^{a}	6.50±0.14^{a}
P- value	<0.01	<0.01	0.07	<0.01	<0.01	0.84

$^{a\,b\,c}$ means in the column with the same superscript are not significantly different (P < 0.05).

3.2 Constraints and opportunities of milk production

3.2.1 Constraints

The study household identified several critical constraints affecting crossbred dairy cattle production (Table 4). Limited available land (33.33%) poses a significant obstacle to efficient dairy farming. Grazing space and cultivation areas for improved forage are in short supply. The expense (20%) associated with feeding the cattle is a major concern. Balancing cost-effective nutrition with production is critical. Achieving optimal milk yield (20%) remains a challenge. Factors affecting production need careful consideration. Skilled professionals (16.66%) are essential for successful artificial insemination. Addressing this shortage is critical for breeding programs. Availability of credit (10%) impacts investment in dairy farming. Accessible credit services can facilitate growth.

According to Getabalew *et al*. (2019), broader constraints in Ethiopian dairy production include disease and parasite management, poor cattle performance, insufficient veterinary

services, labor shortages and lack of artificial insemination services. Ayalew and Abatenhe (2017) highlighted feed and land shortages as major challenges across different regions in Ethiopia. Unbalanced feed costs (including concentrate feed, mill byproducts, roughage, and forage seeds) also contribute to these challenges. To address these issues, collaborative efforts involving farmers, researchers, and extension workers are essential for sustainable dairy production.

Table 1. The rank of constraint on crossbred dairy cow production in the household in the Gidole town

Constraints	N=60	Percent	Rank
Shortage of land	20	33.33	1st
High feed cost	12	20.00	2nd
Low milk production	12	20.00	2nd
Lack of well-trained artificial insemination technicians	10	16.66	3rd
Access to credit	6	10.00	4th

3.2.2 Opportunity

Table 5 presents several possibilities for enhancing crossbred dairy cattle production in the study area. As the population grows (40%), so does the potential for increased milk consumption. A larger consumer base creates demand for dairy products. Consumer income (26.66%) directly influences dairy product demand. Stable revenue sources contribute to sustained market growth. Educating farmers (20%) about best practices and modern techniques is crucial. Extension services play a vital role in disseminating knowledge. Dairy production generates employment (13.33%) opportunities. From on-farm activities to processing and distribution, the entire dairy chain benefits.

Previous study by Solomon (2014) and Kassa (2019) revealed comparable opportunities: rapidly rising populations, particularly in urban areas, increased milk consumption, and dairy production generates income for producers. Small-scale milk production not only enhances food security but also supports rural employment. The dairy industry plays a critical role in Ethiopia's rural economy, especially in highland and pastoral regions. Continued urbanization and increasing demand for milk position the dairy sector for significant contributions to income generation, food security, and employment (Hemme and Otte, 2010). Strategic efforts to capitalize on these opportunities can lead to sustainable growth in crossbred dairy cattle production.

Table 5. Ranks on opportunity for crossbred dairy cow production in the household in the Gidole town

Opportunity	N=60	Percent	Rank
Increasing population growth	24	40	1st
Consumer income source	16	26.66	2nd
Awareness through extension service	12	20	3rd
Expanding employment	8	13.33	4th

4. Conclusions

Crop residues, particularly '*teff*' straw, crop aftermath grazing, hay, improved forages (primarily elephant grass, *desho* grass (*Pennisetum pedicellatum*), Guatemala grass), *enset* pseudo stem, root and leaf, roughages, and non-conventional feeds, were identified as the main feed resources in the study area. Several physiological factors of the cow, as well as other external factors, influence established milk production and components. In the current study, feeding systems of various categories have a significant influence on milk yield and milk composition. The major constraints of cross-breed dairy cows in the study area were a lack of quality and quantity of feed, lack of land, high feed costs, low milk yield, and access to credit services. On the other hand, the major opportunities of producing milk in the study area were high demand for milk, capacity for income generation, job creation, and increased farmers' awareness through extension services. The feeding system of the cow in the household can affect not only the yield of cow milk but also many intermediary products such as butter and cheese of small-scale rural processors. Farm-level production and feed management should be aware of the effect of feed and feeding on milk yield and components. According to the study, there is an opportunity to develop management strategies for the smallholder dairy sector by implementing a farm-level feeding system.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

We are grateful for the financial assistance received from Arba Minch University in Ethiopia.

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Research Article

Registration of the Oat (*Avena sativa*) variety "Walqaa" for vertisols in the Central Highlands of Ethiopia

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Abstract

In this study, fifteen oat varieties including the standard checks were evaluated for agro-morphological traits, nutritional qualities, disease, and insect pest reactions during the main cropping seasons of 2015-2018. Based on the overall performance, two best-performing oat varieties (CI-1742 and SRCPX80Ab2596) were selected and verified with the two standard checks at the Kuyu and Ginchi sub-site of Holetta Agricultural Research Center during the main cropping season of 2018. The overall mean result indicated that the released variety, Walqaa (SRCPX80Ab2596), showed the highest mean DM yield followed by the recent check (SRCPX80Ab2291) while the check variety (CI-8251) which was released earlier and commonly used for vertisol gave the lowest DM yield. Walqaa (SRCPX80Ab2596) had the highest percent increase in DM yield, CP yield, and digestible yield advantages over the standard check variety (CI-8251) which was released earlier and commonly used for vertisol conditions. Similarly, the Walqaa (SRCPX80Ab2596) had a relatively better percent increase in DM yield, CP yield, and digestible yield advantages over the recently released variety (SRCPX80Ab2291). Moreover, the Walqaa (SRCPX80Ab2596) had seeds yield advantage over the earlier released variety (CI-8251). The nutritional qualities indicated that the candidate varieties had advantages over the standard check variety (CI-8251) in terms of the leaf-to-stem ratio, CP, and IVDMD contents. Generally, the Walqaa (SRCPX80Ab2596) had a relatively better leaf-to-stem ratio, CP, and IVDMD advantages over the standard check variety (CI-8251). The national variety releasing committee evaluated the varieties at field conditions in October 2018. Based on their evaluation result, oat variety Walqaa (SRCPX80Ab2596) was officially released in November 2019 for production in the high altitude areas and similar agro-ecologies of the country. The pre-basic and basic seeds of the released variety Walqaa (SRCPX80Ab2596) are maintained by the feeds and nutrition research program of Holetta Agricultural Research Center.

Keywords: Oat; Quality; Variety release; Variety verification; Yield

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https://doi.org/10.59122/14438nb

Received September 22, 2023; Accepted October 30, 2023; Published December, 2023

1. Introduction

Among other cultivated forage crops, oat (*Avena sativa* L.) is widely utilized in the highland farming system of Ethiopia. It is adapted to a wide range of soil types, altitudes and rainfall conditions. It can tolerate waterlogged conditions better than most of the other cereals (Alemayehu, 1997). As compared to the other cereal crops, oat is broadly adapted to marginal environments with low fertility soils, cool-wet and low rainfall climates (Hoffman, 1995; Buerstmayr et al., 2007; Ren et al., 2007). It is widely known that oat varieties are relatively best in cool and moist climates, have poor soil fertility status, and tolerate a very wide pH range and soils of poor drainage, fertility, and texture (Boonman, 1993). IAR (1987) have also reported that experiments done in the different testing sites in the highlands showed adaptations to waterlogging, resistance to diseases except for rust, performs better on poor soils and its utilization as forage becomes widely practiced. Oat is used for human food and livestock feed worldwide (Peterson et al., 2005; Achleitner et al., 2008). Oat is a dual-purpose crop and is used as both forage and grain (Suttie and Reynolds, 2004). It is a good source of energy, protein, vitamin B, phosphorus, and iron (Tiwana et al., 2008). It has adequate soluble carbohydrates and fibers (Peterson et al., 2005). The availability of good quality forage along with sufficient quality is essential to maintain a high level of milk and meat production in the country. Oat forms an exceptional fodder crop because of its excellent growth habit, quick regeneration ability, high palatability, succulence, and high nutritive value for animals.

Thousands of oat lines have been collected and tested for environmental adaptation and forage yield in the highlands (Astatke, 1976). Although some 20-25 varieties have been selected and maintained, their characteristic diversity has not been well investigated. Until recently, the focus of research works on forage crops in general and oats, in particular, has been limited to the evaluation and selection of species or varieties in terms of adaptation to edaphic and agro-ecological conditions as well as herbage yield potential. Choosing the proper variety for a given situation is a good step toward efficient production through further improvement. However, environmental adaptation and herbage yield alone is not adequate parameters to characterize and develop a variety for a given purpose. Recent observation of twenty-one oat varieties selected from both previous world collections and CIMMYT introduction at Holetta has indicated that the varieties are quite different in most of the major traits/parameters measured such as plant height, herbage yield, and grain yield.

In Ethiopia, vertisol covers 10.2% or 12.5 million ha of which 7.6 million ha occur in the Ethiopian highlands and are the fourth most important soils after Lithosol (16.2%), Cambisol (15.3%) and Nitosol (11.8%) (Mesfin and Jutzi, 1989). Despite this soil is very fertile, its productivity is constrained by unique soil physical properties. Due to the high water-holding capacity of this soil, aeration becomes a limiting factor for root growth and activity unless counterbalanced by morphological and physiological adaptation of the roots. Muluneh (2006) reported that the yield of vetch species produced on red soil (Holetta) was more than double compared to the results recorded on black soil (Ginchi) because the soil of Ginchi site is waterlogged which inhibits soil aeration, nutrient absorption and root growth that made plants stunted and reduced growth rate. Getnet and Ledin (2001) also reported that soil type was found to be the most important factor affecting biomass yield and hence herbage production on the well-drained red soil was almost double compared to the black soil. Different varieties respond differently to different soil types, climatic, and management conditions. Recommendations made on oats so far have been on some general aspects of the varieties, mainly environmental adaptation and herbage yield. Accordingly, few varieties have informally reached and being under production by farmers in some areas of the highlands. However, from some formal and informal surveys made in the highlands, it has generally been realized that the lack of specific recommendations for specific purposes has been the major problem faced by farmers concerning oat utilization as livestock feed. Accordingly, the selection of promising oat varieties for vertisol conditions is vital to improving the productivity of these varieties under black vertisols. Therefore, this paper presents the forage yield performance, nutritional qualities, agro-ecological adaptation, disease reaction, and other morpho-agronomic and management recommendations of the recently released oat variety Walqaa (SRCPX80Ab2596) for vertisol conditions.

2. Materials and Methods

2.1. Description of the study sites

This study was conducted in the central highlands at Kuyu and Ginchi sub-sites of Holetta Agricultural Research Center during the main cropping seasons of 2015-2018 under rainfed conditions. The rainfall of the study sites is bimodal and about 70% of the precipitation falls in the period from June to September, while the remaining 30% falls in the period from March to May. The trial sites' geographical position and physicochemical properties of the soil are summarized in Table 1.

Table 1. Test locations and physicochemical properties of the soils

Parameters	Kuyu	Ginchi
Latitude	9° 00'N	9°02’N
Longitude	38° 30'E	38°12’E
Altitude (masl)	2400	2200
Distance from Addis Ababa (km)	29	75
Annual Rainfall (mm)	1044	1095
Daily minimum temperature (°C)	6.2	8.4
Daily maximum temperature (°C)	21.2	24.6
Soil type	Vertisol	Vertisol
Textural class	Clay	Clay
pH(1:1 H_2o)	5.63	6.50
Total organic matter (%)	5.63	1.30
Total nitrogen (%)	0.16	0.13
Available phosphorus (ppm)	6.95	16.50

2.2 Experimental materials, design, and layout

One hundred fifty oat accessions were screened for one cropping season in terms of yield and yield components at Kuyu sub-site of Holetta Agricultural Research Center and the best performing twenty accessions were selected and advanced for further evaluation at Kuyu and Ginchi locations for two cropping seasons.

Based on yield performance data, the fifteen best-performing accessions were selected and promoted to advanced variety trial for two years at Kuyu and Ginchi trial sites. Similarly, based on two years of yield performance data and nutritive values, two promising varieties (CI-1742 and SRCPX80Ab2596) were selected to be verified for their better yield performances and nutritional qualities at Kuyu and Ginchi trial sites. Non replicated 10m x 10m plot size was used for verification of the varieties. The recommended seeding rate of 100 kg/ha was used at sowing and the seed was sown in rows of 20 cm.

Diammonium Phosphate (DAP) fertilizer at the rate of 100 kg/ha was uniformly applied to all varieties during sowing. All recommended management practices were uniformly applied for all varieties during the experimental periods.

2.3. Data collection and sampling

Measurements of plant height were taken from three plants randomly in each plot using a height measuring meter from the ground level to the tip of the panicle. For the determination of biomass yield, varieties were harvested at the forage harvesting stage.

The weight of the total fresh biomass yield was recorded from each plot in the field and the estimated 500 g of their representative samples were taken from each plot to the laboratory. The estimated 500 g sample taken from each plot was weighed to know the total sample fresh weight using a sensitive table balance and manually fractionated into leaf and stem. The morphological parts were separately weighed to know their sample fresh weight, oven-dried for 72 hours at a temperature of 65^{o}C, and separately weighed to estimate the proportions of these morphological parts. The proportion of each morphological fraction in percent was then computed as the ratio of each dry biomass fraction to total dry biomass multiplied by 100.

The crude protein yield was calculated by multiplying crude protein content with the total biomass yield and then dividing by 100%. The digestible yield was also determined by multiplying IVDMD with the total biomass yield and then dividing by 100%.

2.4. Laboratory analysis

The oven-dried samples, at a temperature of 65^{o}C for 72 hours, were used for laboratory analysis to determine the chemical composition and *in vitro* dry matter digestibility of the varieties. The dried samples were then ground to pass a 1-mm sieve and the ground samples were used for laboratory analysis. The analysis was made for the different nutritional parameters. Total ash content was determined by oven drying the samples at 105^{0}C overnight and by combusting the samples in a muffle furnace at 550^{o}C for 6 hours (AOAC, 1990).

Nitrogen (N) content was determined following the micro-Kjeldahl digestion, distillation, and titration procedures (AOAC, 1995), and the crude protein (CP) content was estimated by multiplying the N content by 6.25. The structural plant constituents like neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson procedure (1985). The *in vitro* dry matter digestibility (IVDMD) was determined according to the Tilley and Terry procedure (1963).

3. Results and Discussion

3.1. Adaptation

The released variety Walqaa (SRCPX80Ab2596) is well adapted for the high-altitude areas of the country. The variety performed very well in areas with an altitude of 1500 to 3000 meters above sea level which has an annual rainfall of 700 to 1500 mm. It could also be possible to extend the production of the released variety to other areas with similar agro-ecologies after doing adaptation trials. The released variety produces relatively better forage DM yield when the

recommended fertilizer rate and seeding rate are applied in vertisol and other soil types at planting. Generally, the released oat variety has better forage DM yield and seed yield performance in the high-altitude areas when the variety sown after the first shower of rain in June.

3.2. Varietal evaluation

Two best-performing varieties of oat (CI-1742 and SRCPX80Ab2596) were selected from fifteen varieties for a Variety Verification Trial (VVT). The selected two varieties of oat were sown at Kuyu and Ginchi sub-site of Holetta Agricultural Research Center and sub-site. The National Variety Releasing Committee (NVRC) evaluated the varieties at field conditions in October 2018. Based on their evaluation result, the best-performing oat variety Walqaa (SRCPX80Ab2596) was officially released in November 2019 to be utilized by various end-users in the highland areas. The mean plant height of the candidate varieties with the standard checks is summarized in Table 2. The result indicated that the released variety had the highest mean plant height when compared to other varieties and the two standard checks.

Table 2. Average plant height (cm) of oat varieties at Holetta Agricultural Research Center sub-sites

	Location		
Variety	Kuyu	Ginchi	Mean
CI-1742	105.0	75.0	90.0
SRCPX80Ab2596	140.0	88.3	114.2
R. Check: SRCPX80Ab2291	115.8	105.0	110.4
Check for vertisol: CI-8251	134.2	81.7	108.0
Mean	123.8	87.5	105.7

R. check = Recent check

3.3. Agro-morphological characteristics

The released oat variety Walqaa (SRCPX80Ab2596) adapted well and gave better forage biomass yield in the highland areas ranging in altitude from 1500 to 3000 masl. The performance of the released oat variety is promising in the areas where annual rainfall ranges from 700 to 1500 mm. The released variety gave better forage biomass yield and seed yield in vertisol and other soil types. Despite vertisol is very fertile, its productivity is highly constrained by unique soil physical properties. However, the released variety tolerates the waterlogging and aeration problems to produce better yield under vertisol conditions.

The released variety Walqaa (SRCPX80Ab2596) requires 85 to 100 days after planting to reach the forage harvesting stage. At the forage harvesting stage, the variety has a better leaf-to-stem ratio which is a good indication of quality feed. The released variety produces better forage

biomass yield and seed yield when planted with a seeding rate of 100 kg/ha. The spacing of 20 cm between rows gave a better yield when the variety was sown with rows. For better establishment and yield, Diammonium Phosphate (DAP) fertilizer at the rate of 100 kg/ha should be applied at planting and the variety should be sown in early June. A summary of agro-morphological and nutritional characteristics of the released oat variety Walqaa (SRCPX80Ab2596) is indicated in Table 3.

Table 3. Agronomical, morphological and nutritional characteristics of Walqaa (SRCPX80Ab2596)

Characteristics	**SRCPX80Ab2596**
Species	*Avena sativa*
Common name:	oat
Variety name:	Walqaa (ዋልቃ) (SRCPX80Ab2596)
Adaptation:	For highland areas
Soil type:	Vertisol
Altitude (m.a.s.l):	1500 – 3000
Rainfall (mm):	700 – 1500
Seeding rate (kg/ha):	75 – 100
Row planting (kg/ha)	75
Broadcasting (kg/ha)	100
Spacing for row planting (cm):	Inter-rows 20
Planting date:	Early June
Fertilizer rate (kg/ha):	100 kg DAP or 46/18 kg N/P_2O_5
Time of fertilizer application:	DAP at planting
Plant height at forage harvest (cm):	100 – 140
Days to forage harvesting (soft dough stage):	85 – 100
Days to seed harvesting	145 – 155
Leaf to stem ratio	1.0 – 1.2
Yield (qt/ha):	
Forage dry matter (DM):	50 – 100
Seed:	10 – 20
CP:	3.88 – 7.75
Digestible:	26.92 – 53.84
Straw:	60.0 – 100.0
1000 seed weight (gm):	30 – 35
Harvest index (%):	10 – 20
Fodder quality (g/kg DM):	
Ash:	97.7
CP:	77.5
NDF:	712.6
ADF:	483.0
ADL:	114.7
IVDMD:	538.4
Year of release	2019
Breeder/maintainer	HARC

3.4. Yield performance

The forage biomass yield performance of oat varieties varied across locations during the experimental periods (Table 4). The result indicated that the highest mean DM yield (7.94 t/ha) was recorded at Kuyu while the Ginchi site produced the lowest (5.00 t/ha) mean DM yield. The released variety Walqaa (SRCPX80Ab2596) gave the highest mean DM yield (7.17 t/ha) followed by the recent check (SRCPX80Ab2291) while the check variety (CI-8251) which was commonly used for vertisol gave the lowest (5.61 t/ha) DM yield. The result indicated that the candidate varieties had percent yield advantages over the standard check which was commonly used for vertisol (Table 5).

Table 4. Forage biomass yields (t/ha) of oat varieties tested at Holetta Agricultural Research Center sub-sites

	Location		
Variety	Kuyu	Ginchi	Mean
CI-1742	7.77	4.95	6.36
SRCPX80Ab2596	9.30	5.04	7.17
R. Check: SRCPX80Ab2291	7.06	6.44	6.75
Check for vertisol: CI-8251	7.63	3.58	5.61
Mean	7.94	5.00	6.47

R. check = Recent check

The candidate varieties had the highest percent increase in DM, CP and IVDMD yields over the standard check variety which was commonly used for vertisol. The released variety Walqaa (SRCPX80Ab2596) produced the highest percent increase in DM yield of 27.81 and 6.22% over the standard check CI-8251 and SRCPX80Ab2291 variety, respectively. Moreover, 36.59 and 5.66% increases in CP yield were recorded for the released variety Walqaa over the standard check CI-8251 and SRCPX80Ab2291 variety, respectively.

Table 5. The yields percent increase of oat varieties over the standard checks

Variety	DM Yield	% increase	CP yield	% increase	IVDMD yield	% increase
CI-1742	6.36	-5.78 (13.37)	0.50	-5.66 (21.95)	3.40	-6.85 (15.25)
SRCPX80Ab2596	7.17	6.22 (27.81)	0.56	5.66 (36.59)	3.86	5.75 (29.53)
R. Check: SRCPX80Ab2291	6.75	-	0.53	-	3.65	-
Check for vertisol: CI-8251	5.61	-	0.41	-	2.98	-

R. check = Recent check; Number in parenthesis indicates % increase from the check which is commonly used for vertisol (CI-8251)

Similarly, 29.53 and 5.75% increase in IVDMD were recorded for the released variety Walqaa over the standard check CI-8251 and SRCPX80Ab2291 variety, respectively. Generally,

the released variety Walqaa (SRCPX80Ab2596) gave the highest percent increase in DM yield, CP yield, and digestible yield advantages over the two standard checks.

The seed yield performance of oat varieties is indicated in Table 6. The result showed that the highest mean seed yield (15.68 qt/ha) was recorded at Kuyu while the Ginchi site produced relatively the lowest (15.13 qt/ha) seed yield under vertisol conditions. The candidate variety (CI-1742) gave the highest mean seed yield (16.70 qt/ha) followed by the released variety Walqaa (SRCPX80Ab2596) while the variety released earlier and commonly used for vertisol (CI-8251) produced the lowest seed yield. Generally, the released variety Walqaa (SRCPX80Ab2596) had a 6.01% increase in seed yield over the previously released and commonly used vertisol variety (CI-8251).

Table 6. Seed yield (qt/ha) of oat varieties and their mean seed yield advantage over the standard checks.

Variety	Locations		Mean	% Increase over checks
	Kuyu	Ginchi		
CI-1742	16.45	16.94	16.70	13.07 (14.07)
SRCPX80Ab2596	15.02	16.01	15.52	5.08 (6.01)
R. Check: SRCPX80Ab2291	15.90	13.64	14.77	
Check for vertisol: CI-8251	15.35	13.92	14.64	
Mean	15.68	15.13	15.41	

R. check = Recent check; Number in parenthesis indicates percent increase over the check for vertisol (CI-8251)

3.5. Quality attributes

The chemical composition and *in-vitro* dry matter digestibility of oat varieties are summarized in Table 7. The result indicated that the candidate variety (CI-1742) had the highest (108.3 g/kg DM) ash content followed by the recently released standard check variety (SRCPX80Ab2291) which had an ash content of 106.8 g/kg DM, indicating a high mineral concentration in the plant. On the other hand, the standard check variety (CI-8251) which was released earlier and used commonly for vertisol had the lowest (93.9 g/kg DM) ash content followed by the currently released variety named Walqaa (SRCPX80Ab2596) which had an ash content of 97.7 g/kg DM.

The CP content of the tested oat varieties showed a difference, ranging from 72.7 to 79.0 g/kg DM. The highest CP content (79.0 g/kg DM) was recorded for the recently released standard check variety (SRCPX80Ab2291) followed by variety CI-1742 and the Walqaa (SRCPX80Ab2596) variety while the earlier released standard check variety (CI-8251) gave the lowest CP content. The lowest NDF (701.0 g/kg DM) and ADF (454.4 g/kg DM) contents were recorded for the earlier standard check variety (CI-8251) while the candidate variety (CI-1742)

had the lowest (454.4 g/kg DM) ADL content when compared to other varieties. On the other hand, variety CI-1742, the recently released variety (SRCPX80Ab2291) and the standard check variety (CI-8251) showed the highest NDF (730.2 g/kg DM), ADF (509.4 g/kg DM) and ADL (116.5 g/kg DM) contents, respectively.

Table 7. Chemical compositions and *in-vitro* dry matter digestibility of oat varieties

	g/kg DM					
Variety	Ash	CP	NDF	ADF	ADL	IVDMD
CI-1742	108.3	78.5	730.2	490.8	102.6	534.4
SRCPX80Ab2596	97.7	77.5	712.6	483.0	114.7	538.4
R. Check: SRCPX80Ab2291	106.8	79.0	727.2	509.4	111.6	540.7
Check for vertisol: CI-8251	93.9	72.7	701.0	454.4	116.5	531.8

R. check = Recent check

Table 8. Percent increases of oat varieties over the standard checks

Variety	LSR	% increase	CP	% increase	IVDMD	% increase
CI-1742	1.02	8.5		-0.63		-1.17
		(7.4)	7.85	(7.98)	53.44	(0.49)
SRCPX 80Ab2596	1.17	24.5		-1.90		-0.43
		(23.2)	7.75	(6.60)	53.84	(1.24)
R. Check SRCPX80Ab2291	0.94	-	7.90	-	54.07	-
Check for vertisol: CI-8251	0.95	-	7.27	-	53.18	-

R. check = Recent check; LSR= Leaf to stem ratio; CP= Crude protein; IVOMD= in-vitro dry matter digestibility; Number in parenthesis indicates % increase from the check which commonly used for vertisol (CI-8251)

The IVDMD contents of the tested oat varieties ranged from 531.8 to 540.7 g/kg DM. The SRCPX80Ab2291 produced the highest IVDMD content followed by the Walqaa (SRCPX80Ab2596) while the standard variety (CI-8251) gave the lowest IVDMD content. The candidate varieties had advantages over the standard check variety which was released and commonly used for vertisol in terms of the leaf-to-stem ratio, CP and IVDMD (Table 8). The result indicated that the highest percent increase (23.2%) in the leaf-to-stem ratio was recorded for the Walqaa (SRCPX80Ab2596) over the standard check variety (CI-8251) which was released earlier and commonly used for vertisol.

The highest CP percent increase of 7.98 and 6.60% over the standard check was recorded for CI-1742 and the Walqaa (SRCPX80Ab2596), respectively. The IVDMD of the candidate varieties also showed an advantage over the standard check variety (CI-8251). The Walqaa (SRCPX80Ab2596) showed IVDMD advantages of 1.24% over the standard check variety (CI-8251).

3.6. Reaction to diseases and pests

Data recording on major diseases and insect pests was done for all oat varieties starting from preliminary observation in the test locations. Based on the standard rating scale of 1-9, where 1 is highly resistant and 9 is highly susceptible, the candidate varieties were found to be tolerant to moderately tolerant for the recorded major disease and insect pests in the test locations during the study periods. No chemical was applied during the evaluation of the varieties starting from the initial screening to verification to control the major disease and insect pests. The Walqaa (SRCPX80Ab2596) was tested for its diseases and insect pests reactions and found to be tolerant to major diseases and insect pests which can affect the variety. The tolerance reaction of the variety could be integrated with other diseases and insect pests' management strategies for better results. Generally, the released variety had better tolerance to major diseases and insect pests.

4. Conclusion

The morpho-agronomic performance and nutritional characteristics of tested oat varieties varied across the test environments due to the differential response of the varieties to various biotic and abiotic factors. The released variety Walqaa (SRCPX80Ab2596**)** adapted and gave better yield in the highland areas ranging in altitude from 1500 to 3000 masl. The performance of the released variety is promising in the areas where annual rainfall ranges from 700 to 1500 mm. The released variety has better forage biomass yield and seed yield on vertisol and other soil types. The released variety produces better forage DM yield and seed yield when a recommended fertilizer rate and seeding rate are applied at planting. The nutritional qualities indicated that the candidate varieties had advantages over the standard check variety in terms of the leaf-to-stem ratio, CP, and IVDMD contents. Generally, the released variety Walqaa (SRCPX80Ab2596) had relatively better leaf-to-stem ratio, CP, and IVDMD contents advantages over the standard check (CI-8251) variety which was released earlier and commonly used for vertisol conditions. Therefore, the national variety releasing committee evaluated the varieties at field conditions in October 2018. Based on their evaluation result, oat variety Walqaa (SRCPX80Ab2596) was officially released in November 2019 for production in the high-altitude areas and similar agro-ecologies of the country. The pre-basic and basic seeds of the released variety are maintained by the feeds and nutrition research program of Holetta Agricultural Research Center.

Acknowledgments

The authors would like to thank the Ethiopian Institute of Agricultural Research (EIAR) and the Agricultural Growth Program-II (AGP-II) project for the financial support of this study. All researchers and responsible persons who participated directly or indirectly from respective research centers are also highly acknowledged for their smooth communication and exchange of valuable information during the entire course of this activity. Moreover, the animal nutrition research staff of Holetta Agricultural Research Center is duly acknowledged for their assistance in the laboratory analysis.

Conflict of Interest

There is no conflict of interest, according to the authors.

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Research Article

Crossbreed dairy cow production, feeding and management practice at Gidole town, South Ethiopia

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Abstract

The study aimed to evaluate the production, feeding, and management techniques of Holstein Friesian (HF) crossbred dairy cows at Gidole town, south Ethiopia. Cross-sectional survey involving 60 households selected through systematic random sampling from a total of 150 households with crossbred HF dairy cows in the town. Chemical compositional analysis performed on key feed items collected from the study households. Data analyzed using the Statistical Package for the Social Sciences software. Average daily milk yield was 7.29±0.22 liters, while average lactation milk yield was 1727.73±9.57 liters. The average lactation length was 7.9±1.45 months. While 53.3% of households possessed crossbreed cows with a blood level of 50%, 43.3% had cows with a blood level of 50-75% and 3.3% had cows with a blood level beyond 75%. Crop residue, improved forages (desho, Guatemala, and elephant grass), enset, atella, and salt were the most important cattle feed resources. In the non-conventional diet, atella has the highest crude protein (CP) content (29.24%), followed by elephant grass (18.44%) and teff straw (6.34%). Despite its importance, feed availability remains a challenge in terms of both quality and quantity. To address this, the study recommends strong extension efforts focused on: promoting the use of concentrate feed, developing and utilizing improved forage options and treating crop residues to enhance their quality.

Keywords: Crossbred dairy cow; Feed; Feeding practices; Gidole; Milk production

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https://doi.org/10.59122/14438wx

Received August 8, 2023; Accepted October 18, 2023; Published December, 2023

1. Introduction

Ethiopia's diverse agro-ecological zones and large livestock population make it a significant hub for livestock in Africa (Ayalew and Abateneh, 2019). The majority of cattle are indigenous breeds, with a small percentage being crossbred and fewer pure exotic breeds. Livestock, particularly dairy production, plays a crucial role in the country's agricultural and socio-economic landscape. However, challenges such as feed scarcity, poor management, and low genetic potential hinder milk production and overall productivity. Much of the available feed

resources are utilized to support the maintenance requirements of the animals, with little surplus for production. There is marked seasonality in the quantity and quality of available feed resources due to various environmental determinants such as drought and frost (Jimma et al., 2016) and poor management and conservation techniques.

Livestock feed resources are classified as natural pasture, crop residue, aftermath grazing, and fodder, of which the first two contribute the largest feed type (CSA, 2012). The contribution to these feed resources, however, depends on the agro-ecology, the type of crop produced, accessibility, and production system (Ahmed et al., 2010). To meet the future demand, production of milk, including milk production per lactating cow, would need to be significantly increased if the available feed resources were sufficient, especially in terms of DM, CP, and ME. Moreover, unbalanced feeding could lead to the excess feeding of some nutrients while others remain deficient. This not only reduces productivity and increases costs per kg of product but also affects various physiological functions, including long-term animal health, fertility, and productivity (Yisehak & Geert, 2014).

Crossbreeding native cattle has been suggested as the most effective and quickest method of genetically enhancing the productivity of regional dairy herds. Crossbred cows are thought to have higher genetic potential and produce more milk than native cows (Lembeye et al., 2016; Getahun, 2022). However, crossbred and exotic cattle breeds account for only 1.62% and 0.18% of Ethiopia's total cow population, respectively (Getahun, 2022). Even crossbred cow milk output is low under farmer management, which is attributed to inadequate feeding and management circumstances (Hatew et al., 2023). Efforts to increase indigenous bovine milk output through crossbreeding with exotic genotypes under smallholder farmer settings in Ethiopia have yielded minimal results.

Milk output from these crossbred cows has yet to reach its full potential, producing enough milk and dairy products to meet domestic demand. Implementing genetic improvement strategies in smallholder crossbred populations presents numerous challenges, the most significant of which is a lack of performance or pedigree recording, as well as uncertainty about what accuracy can be achieved when herd sizes are small and production environments vary greatly between farms and over time (Rao et al., 2014).

Funding and action fatigue are barriers to commencing genetic improvement in such populations due to the significant lag time between when performance recording begins and when enough pedigree information is acquired to provide breeding values (Al Kalaldeh et al.,

2021). However, to achieve a specific level of milk yield potential in crossbred cows, equivalent improvements in management and feeding are required (Tekeba et al., 2014). According to Haile et al. (2009), despite the potential for increased milk production with higher intervention levels, traditional smallholder management and feeding techniques are often regarded as insufficient to sustainably support the higher productivity potential of crossbred cows in Ethiopia. Tekeba et al. (2014) explored the interplay between genetic potential and the plane of nutrition and discovered that management systems and supplementing conventional diets supplied to cows with energy and protein-rich concentrates resulted in higher daily milk production.

Additionally, they reported that improved nutrition helped crossbred cows significantly more than native cows in terms of milk production and body condition maintenance, crucial factors in reproductive success. Therefore, the main obstacle to the development of Ethiopia's livestock subsector is the paucity of feed in both the quantity and quality dimensions. In Ethiopia, the adoption of better dairy husbandry techniques is positively and significantly correlated with training in dairy farming, aside from feed (Dehinenet et al., 2014; Samuel et al., 2016).

This study aimed to assess the production system and management conditions of crossbreed dairy cows at Gidole town, South Ethiopia. In Derashe special district, Gidole town, improved or crossbred dairying plays a vital role in the livelihood of the farming community. This activity serves both as a source of income generation and as a means to meet family milk needs.

The emergence of small-scale, market-oriented urban dairy production has gained popularity, contributing significantly to bridging the demand-supply gap for milk and milk-based products. This gap arises due to population growth, income dynamics, and urban expansion. Despite its importance, challenges persist. Smallholder semi-urban dairy producers at Gidole town face obstacles related to feed scarcity, subpar feed quality, and inadequate feeding management practices.

As a result, milk production from the cows they rear remains disappointingly low. Efforts to address these challenges are crucial for sustaining dairy production, improving livelihoods, and meeting the growing demand for dairy products in the region.

2. Materials and Methods

2.1. Descriptions of the study area

This study was conducted in Derashe special district to examine the production, feeding and management practices of Holstein Friesian crossbred dairy cows at Gidole town. Gidole is the capital town of Derashe and is about 550 km away from Addis Ababa, the capital city. Derashe has an estimated area of 148,700 hectares (SASA, 2016). Among the total area, 50514.14 (33.97) hectares are cultivated land, 7589.5 hectares are rangeland, 17,165.38 hectares are forest, 16278.18 hectares are water bodies, and 57152.8 hectares are others (21051 hectares of settlement, 15561.8 hectares of arable land, and 20540 hectares of unarable land).

Derashe shares borders with Amaro and Konso Zone in the east, Alle district and Gamo Zone in the west, Gamo Zone in the north, and Konso Zone and Alle district in the south. Astronomically, the district extends from 5.390–5.780 N latitudes and 37.010–37.560 E longitudes. Its altitude (elevation) ranges from 501 to 2500 meters above sea level (SASA, 2016). According to the 2007 Census report, the total population of the district was about 140,197, of which the male population is 68,471 and the female population is 71,726 (CSA, 2007).

It is estimated that about 119,127 (84.97%) of the population live in rural areas, of which 58,081 (48.75%) are males and 61,046 (51.24%) are females (SASA, 2018). Based on its location and altitude characteristics, it is categorized into three traditional agro-climatic zones: the *Dega* (highland), the *Woyena Dega* (midland), and the *Kolla* (lowland). *Dega* comprises 9.8%, *Woina-Dega* 34.5%, and *Kolla* 55.7% of the total land area of the district (WFEDOASA, 2019). The climate of the area is dry and warm, with relatively low precipitation. It receives two rainy seasons, the *Belg* and *Maher* rainy seasons. *Belg*'s short rainy (cropping) season extends from February to June, whereas *Meher*'s long and main rainy (cropping) season extends from July to December. The long-term mean maximum and minimum temperature are 27.5 °CC, respectively. The dominant soil type in the district is sand soil, which accounts for 48%. The annual rainfall of the district is between 601 mm and 1600 mm (SASA, 2016). Rainfall is irregular and bimodal, peaking around April and October. Feeding recommendations for dairy cows include an optimum ratio of forage to concentrates of 60 to 40%, with variations between 55:45 and 65:35% being optimal in ammonia N levels, free amino acids, and the acetate: propionate ratio (Kljak et al., 2017). The levels of inclusion of concentrates influence milk yield,

fat, and protein. Gidole farmers practice a traditional smallholder mixed crop-livestock agricultural technique.

Livestock have a vital role in the economy of both the region and the study area. Livestock are kept primarily as a source of capital that may be converted into cash when needed, for agricultural cultivation, food for humans, and as a supply of manure to improve soil fertility. The dominant livestock of the area is cattle, which is estimated to be 156,875 head. Small ruminants, poultry, and equines account for around 168,936, 250,000, and 15,000, respectively.

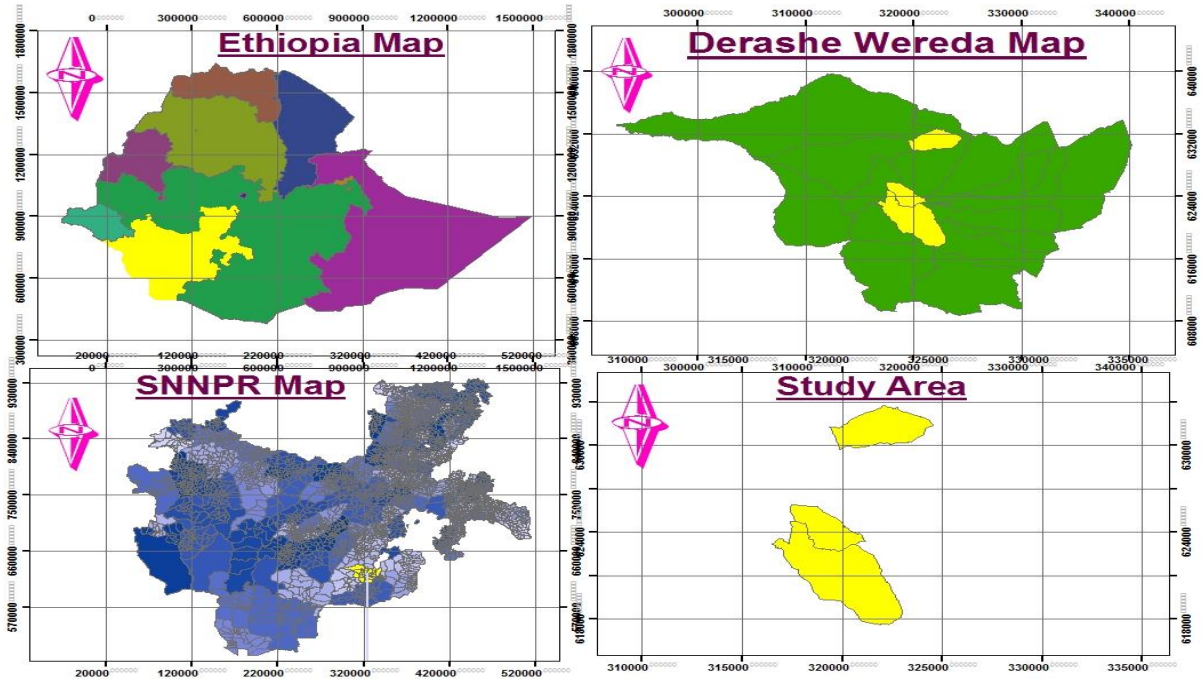

Figure 1. Map of the Derash district in the southern nation nationalities people region of Ethiopia

2.2. Sample size and sampling technique

The purpose of this study was to examine the production system, feeding, and management circumstances of crossbreed dairy cows at Gidole town, utilizing systematic random sampling procedures and a cross-sectional household survey to capture dairy cattle management practices in the study region. The cross-sectional study was conducted in three kebeles of Gidole town: Hallale, Solle, and Layighaw Arguba administrative units (kebeles) with 100% highlands. From a list of 150 households, 60 respondents were selected using systematic random selection techniques from the list of farmers that have Holstein Frisian (HF) crossbred dairy cows in their herd (Table 1). A field study was carried out on urban dairy production systems at Gidole town.

2.3. Data collection

The current study collected data from both primary and secondary sources. The primary data sources came from the study households. Furthermore, in the selected study houses, a daily milk yield and feed type recording sheet were maintained and recorded. Secondary data were gathered from the district and town livestock and fishery resource offices. Initially, the questionnaire examined the blood level (%), parity stage, milk supply, and feeding practice (quantity of feed delivered, type, quality, suppliers, and so on). Data on socioeconomic level, productivity, labor distribution, housing, and cleaning frequency were also collected. Data were obtained using well-prepared questions and qualified enumerators from livestock and fishery resource offices, with the researcher closely monitoring the household interviews. The compositional quality assessment of feedstuffs collected from the intervening household for dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), and ash was conducted at Arba Minch University's College of Agriculture research laboratory.

Table 1. Proportion **s**ample size in each unit (kebele) in the Gidole town

Unit (kebele) selected	THH-crossbred Holstein Frisian cow	Proportion of household	Sample size in each unit (kebele)
Hallale	60	0.4	24
Solle	56	0.37	22
Layighaw Arguba	34	0.23	14
Total	150	1.0	60

THH=Total households

2.3. Data collection

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matter (DM), crude protein (CP), neutral detergent fiber (NDF), and ash was conducted at Arba Minch University's College of Agriculture research laboratory.

2.4. Data analysis

Means and standard errors (SE) were calculated with a significance level of P = 0.05 to determine the impact of diets and feeding procedures on milk yield in the categories. Cross-tab analysis was used to examine the frequency data. Statistical analyses were performed using SPSS 20 for Windows (SPSS Inc., Chicago, USA).

3. Results and Discussion

3.1. Socio-economic characteristics

The socioeconomic characteristics of the respondent households in the study area are shown in Table 2. The age category of the majority (60%) of the respondents was found between 41 and 60 years, followed by 36.7% between 31 and 40 years. There was no significant difference in the age categories of the study households. The age group of the current result is comparable with the result of Megersa (2016), who reported that the majority of respondents' ages ranged from 25 to 62 years in the west Shoa zone, Oromia region, Ethiopia. The current age distribution pattern reflects that young people are less dependent on urban and peri-urban dairy production, which might be due to financial and experience-related problems.

The educational status of the majority of the respondents was in primary school (43.3%), followed by high school (30%) and college and above (26.7%) education (Table 2). There was no significant difference in educational status in the study area. The current result is contrary to the result of Abebe et al. (2017), who reported that the first degree (6.58%) was the highest educational level achieved by household heads in the central highlands of Ethiopia. When farmers have a higher educational level, it helps in better understanding and adoption of new farm technologies as well as better husbandry practices (Lemma et al., 2012; Gizaw et al., 2012). The educational status of the current result indicates that there is a good opportunity to practice dairy farming in a better manner and to transfer knowledge and technologies easily to those small dairy producers to obtain better milk production.

In the current study, the highest percentages of household heads (70%) were male, which implies that higher proportions of males were engaged in dairying than females (30%). There is no significant difference in household head members in the study area (Table 2). The current result of the household head is comparable with the result of Saba (2015), who reported that the

majority of the household heads is male in the Adea Berga and Ejerie districts of the west Shoa zone, Ethiopia. In the central zone of Tigray, Gebrekidan et al. (2012) also indicated that the proportion of male household heads was higher than that of female heads. This indicates that females are less dependent on urban dairy production than males, so attention must be given to the females participation in smallholder dairy farming for work, employment, and income generation.

Table 2. Socio-economic characteristics of the respondent household in the Gidole town

Variable	Frequency	Percent (%)	P- value
Age			
Below 30 years	2	3.3	
Between 31 to 40 years	22	36.7	0.370
Between 41 to 60 years	36	60	
Total	60	100	
Education			
Primary school	26	43.3	
(High school	18	30.0	0.300
College and above study	16	26.7	
Total	60	100	
Sex			
Male	42	70.0	0.240
Female	18	30	
Total	60	100	

3.2. Household income source

The household income source of the study household is shown in (Table 3). Livestock and off-farm activities earn about 40% of the majority of the respondent household income in the study area. While followed by off-farm activities generated 26.7% of the income. However, there is no significant difference in income sources.

Table 3. Income source of the household in the Gidole town

Activity	Frequency	Percent (%)	*P* –value
Crop production	10	16.7	
Off-farm activities	16	26.7	
All activities	2	3.3	
Mixed farming	4	6.7	0.101
Crop and off-farm	4	6.7	
Livestock and off-farm	24	40	
Total	60	100	

The current result is comparable with the result of Kassu (2016) who reported that the majority of the respondents were primarily involved in milk production (78%) followed by

poultry production (14.7%) and goat production (7.3%) in the area of Bona Zuria district of Sidama Zone, southern Ethiopia. The result indicates that a livestock farming practice plays a great role in the generating of household income and work employment.

3.3. Milk yield of crossbred dairy cow

3.3.1. Daily milk yield of crossbred cow

The daily milk yield (DMY) and lactation length of dairy cattle in the study area are shown in (Table 4). The mean value of the daily milk yield of crossbred cows in the study area was 7.29±0.22 liter/day. The reported average daily milk yield of crossbred cows in this study is less than the value of 11.9 and 11 liters/day reported by Getu et al. (2009) and Saba (2015), respectively. Similarly, the higher overall mean daily milk yield per cow was reported from the crossbred dairy cows which was 13.56 ± 1.34 liters, in the Smallholder dairying of the ada'a district of Ethiopia (Habtamu, 2018). A DMY of 11.6 and 10.8 liters were recorded in Bishoftu and Akaki towns, respectively, for crossbred cows (Dessalegn et al., 2016), and in Adama milk shed, it was 11.3 liters (Nigusu & Yoseph, 2014). In Hawassa, a DMY of 10.32 liters for cross-bred cows is recorded (Haile et al., 2012). This result is again less than the findings of Yitaye et al. (2008), who reported 7.8 liters at Bahir Dar and Gondar peri-urban milk sheds, and Yayeh et al. (2017), who reported 7.3 liters in Debre Markos town. However, this result is higher than Asaminew & Eyasu's (2009) reported 5.2 liters of DMY in Bahir Dar Zuria. Demissu (2014) reported that the average daily milk yield in three towns in the Horo Guduru Wollega zone was 7.21 liters. Those findings revealed that the bigger the cities where dairy production is found, the higher the recorded daily milk yield. This could be because bigger cities have better access to inputs like concentrate feeds, AI, veterinary services, and markets. Therefore, to improve the milk productivity of cow inputs like concentrates and industrial by-products, AI, veterinary services, and market accessibility must be facilitated.

3.3.2. Lactation length of crossbred cow

Lactation length refers to the period from the time a cow starts to secrete milk after parturition to the time of drying off. The low lactation lengths and low milk yield of the study area dairy cows might be related to breed, production system, herd management related to feeding, disease, and other environmental factors. The mean lactation length of crossbreed cows in the study area was 7.9±1.45 months. The mean lactation length of the current study was less than the results of Mulugeta & Belayneh (2013) and Ketema (2014), which were 11 months in

North Showa and 10.1 months in Kersa Malima Woreda, respectively. This finding is also lower than 9.17 months in Gondar town (Kumar et al., 2014), 8.7 months in Debre Markos (Yayeh et al., 2017), 10 months in Bahir Dar Zuria (Assaminew & Eyasu, 2009), 10 months in Jimma town (Ulfina et al., 2013), and 9.22 and 9.36 months in Bishoftu and Akaki (Dessalegn et al., 2016).

The average lactation length of crossbred cows in the study area was 7.9±1.45 with an estimated lactation milk yield of 1727.73±9.57 liters (Table 4). This result was low compared to the average lactation period reported by Ike et al. (2005), which was 11.2 months with a lactation

Table 4. Milk yield and lactation length of crossbred dairy cow in the Gidole town

Milk production	Mean ± standard error
Milk yield per day in liter	7.29±0.22
Lactation length (month)	7.9±1.45
Lactation milk yield (year) in liter	1727.73±9.57

yield of 3949.6 liters for cows in urban farms, and also because the current result of lactation milk yield is less than the result of Ike et al. (2005), which was 12.2 months with a lactation yield of 2596.2 liters for cows in peri-urban farms in Awassa.

3.4. Purpose of keeping dairy cow

The purpose of keeping dairy cows is indicated in Table 5. The majority of the households' milk products were for market sale and household consumption (33.3%), for market sale (30%), and for household consumption only (26.7%). This implies that dairy cow milk production in the study area plays a great role in food nutritional security and income generation.

Table 5. Purpose of rearing dairy cows in the household in the Gidole town

Purpose	Frequency	Percent (%)
Market sale only	18	30.0
Free calve suckle and growth only	6	10.0
Household consumption only	16	26.7
Market sales and household consumption	20	33.3
Total	60	100.0

3.5. Breed type and blood level of dairy cow

The breed type of dairy cow in the study area is shown in Table 6. Local breeds made up 63.33% of the breeds of cows in the research area, while crossbreeds made up 36.66%. In the

study area, 53.3% of families possessed crossbreed cows with a blood level of 50%, 43.3% had cows with a blood level of 50–75% and 3.3% had cows with a blood level of more than 75%. This shows that crossbred dairy production in the research area will eventually increase. This dairy system is significantly contributing to closing the massive demand-supply gap for milk and milk-based products driven by population, income, and urban growth. This was an excellent opportunity for dairy farming.

The blood level of dairy cows in the study area was comparable to the results of Melku et al. (2017) and Megersa (2016), who reported that the exotic blood level of crossbred cows was less than 50% in the peri-urban and urban ranges of 50–75% of the exotic blood level in West Gojam Zone, Amhara Region. The study also indicated that the majority of respondents ranked at the first 50–75% exotic blood level of crossbred dairy cows in West Shoa Zone, Oromia, Ethiopia, with an index result of 0.46. The experimental unit of on-farm monitoring and evaluation of the effect of household feed and feeding practices on milk yield of Holstein Friesian crossbred dairy cows was carried out and registered a maximum sample size in a better manner for 12 dairy cows of blood type 50–75% of parity two at the same lactation stage.

Table 6. Breed type and blood level of dairy cow in the household in the Gidole town

Breed type	Frequency	Percent (%)
Local breeds	38	63.33
Crossbreeds	22	36.66
Total	60	100
Blood level (%)		
50	32	53.3
50-75	26	43.3
Above 75	2	3.3
Total	60	100

3.6. Dairy cattle management practices

3.6.1. Labor use of dairy cattle husbandry

Table 7 shows the study results for labor use in dairy cattle husbandry. Women performed the majority of dairy cattle husbandry management duties, including 50% herding, 64% milking, 50% barn cleaning, 50% feeding, 23% live animal sales, and 80% livestock product sales. Men handled 88% of live animal sales, 79% of breeding decisions, and 57% of health management.

The current result is comparable to Kedija's (2008) findings, which revealed that milking is largely done by women in the Meiso district. Men (95.4%) make the majority of decisions

regarding live animal sales and breeding. Similarly, Tesfamichea and Yien (2021) revealed that household members engaged in varied dairy animal husbandry activities in Gambella's lowlands. This research demonstrated that women play a minor role in household decision-making, with men making the majority of decisions. As a result, this outcome demonstrated the importance of gender education in the district so that women might be empowered in all social, economic, cultural, and political contexts.

Table 7. Labor division of the household in dairy cattle husbandry in the Gidole town

Activity	Responsible family members (%)			
	Children	Women	Men	Hired labor
Herding	17	50	23	10
Milking	0	64	26	10
Barn cleaning	15	50	15	20
Sale of animal	0	23	88	0
Feeding	10	50	15	25
Sell of dairy product	0	80	20	0
Caring of calves	35	27	13	25
Breeding decision	0	21	79	0
Health management of dairy cattle	5	23	57	15

3.6.2. Breeding practice

Natural mating and artificial insemination were identified as common breeding practices in the research area, as indicated in Table 8. Natural mating is used by 43.3% of responders, artificial insemination by 50%, and a combination of natural and artificial insemination by 6.7%.

The current result is analogous to that of Desalegn (2008), who found that the proportion of AI users was higher near Addis than in regional locations. Major constraints associated with AI in Ethiopia include a lack of collaboration and regular communication between the National Artificial Insemination Centre (NAIC) and stakeholders, the absence of a proper and functional breeding policy and herd recording system, insufficient resources in terms of inputs and facilities, and the absence of incentives and rewards to motivate AI technicians (Desalegn, 2008). In controlled mating systems, heat detection and timing of service in the study area were carried out by the farmers, and each cow was mated once during each heat period.

During the breeding season, some farmers mate their cows and heifers with the superior bulls owned by themselves or their neighbors. Most of the farmers breed their cows with the best performing crossbred bull available in the herd when their cows come to heat.

Table 8. The mating system of dairy cattle in the Gidole town

Mating systems	Frequency	Percent (%)
Natural mating only	26	43.3
Artificial insemination only	30	50
Both	4	6.7
Total	60	100

3.6.3. Dairy cattle housing and facilities

Dairy cattle housing practices in the study locations is presented in Table 9. All of the respondents (100%) in the research areas kept their cattle in separate houses. The current result's housing system is identical to the Saba (2015) report, which said that all farmers in the Adea Berga and Ejerie districts use housed barns for their cows. Similarly, Ayalew (2017) found that in South Wollo Zone, Dessie town, Ethiopia, all (100%) urban and peri-urban respondents kept their dairy cows in separate houses. Furthermore, 80% of urban dairy farms and 3.33% of peri-urban medium and large dairy farms in Mekelle, Ethiopia, used distinct housing systems (Hulagersh et al., 2017). In contrast to Babege et al. (2020), who reported that 96.7% of respondents shared the same dwelling with their animals in the Cheha District of Gurage Zone. Table 9 shows dairy cattle feed and water trough facilities. The majority of responses (60%) has both feed and water troughs, whereas 40% only have a feed trough. Kibru et al. (2015) found that most farmers in the Aleta Chukko district of southern Ethiopia had stables with water and feed troughs. To summarize, well-designed feeders and drinkers are crucial materials for dairy cows in terms of feed quality maintenance, animal nutrition improvement, and feed waste reduction.

Table 9. Dairy Cattle housing facilities in the Gidole town

Variables	Respondent N=60	Percent
Housing type		
Separate house	60	100
Facilities in the barn		
Feed trough only	24	40
Both feed and water trough	36	60

3.6.4. Frequency of barn cleaning and milking

Table 10 displays the frequency of barn cleaning and milking practices used in the current investigation. The majority of respondents (56.66%) clean the barn once each day, while 43.33% clean it twice per day. The current results are low in comparison to Saba (2015) and Abebe et al. (2012), who reported that the majority of respondents (65%) removed it daily and 35% removed it three times a week in the Adea Berga and Ejerie districts of the West Shoa zone,

respectively. Abebe et al. (2012) observed similar findings, with 47% of respondents cleaning their barn three times per week in Gurage Zone, Ezha district.

Maintaining the sanitary state of the milking environment is critical for clean milk production (Zelalem, 2010). The current research area's milking site was approximately 70% in the barn, with 30% outside the room. The results were comparable to those of Godferey (2013) and Mbabazi (2005), who found that farmers milking their cows in the open air could expose milk to contaminants from the environment, and farmers milking their animals in undesignated, poorly maintained milking shades or parlors predispose milk to contamination and spoilage.

Table 10. Frequency of barn cleaning, and milking area of cows in the Gidole town

Variables	Respondent (N=60)	Percent
Frequency of cleaning barn		
Twice a day	26	43.33
Once a day	34	56.66
Milking parlor		
In the barn	42	70
Outside of the room	18	30

3.6.6. Major feed resource for crossbreed dairy cow

Table 11 shows the ranks of major types of feed resources used for dairy cattle in the study area. The primary feed resources were crop residues (1st rank), improved forages (2nd rank), crop leftovers (*enset*/banana) (3rd rank), and natural pasture (4th rank). The results show that crop residues, enhanced forages, and crop leftovers (*enset*/banana) were the most commonly used diets for cross-bred dairy cattle at Gidole town.

The feed resource observed in the current study was comparable to the results of Ayalew (2017) and Kassu (2016), in which the major feed resources are natural grazing, crop residues, hay, improved forage, agro-industrial byproducts, and non-conventional feedstuffs in the South Wollo Zone. Mesfin (2015) observed natural grassland (57.5%), agricultural leftovers (26.3%), crop aftermaths (16.2%), and crop aftermaths (16.2%) in the Bona Zuria area of Sidama Zone, which contradicts the current result. Today, the relevance of natural pasture is gradually declining due to increased crop production on grazing land and land degradation. This suggests that it requires attention for better forage cultivation and the right use of agricultural leftovers and crop aftermath.

Table 11. Types of feed resources used for dairy cattle in the Gidole town

Feed types	Frequency	Percent	Ranking
Improved forages	8	13.3	2nd
Natural pasture	4	6.7	4th
Crop residues	42	70.0	1st
Crop leftover (*enset*/banana)	6	10.0	3rd
Total	60	100.0	-

3.6.7. Supplementary feed resource of crossbreed dairy cow

Table 12 shows the supplemental feed resource consumption for dairy cattle in the research area. According to the respondents interviewed, *atella* (1st rank), salt (2nd rank), industrial by-products (3rd rank), and a combination of *atella* of all additional feeds (4th rank). Supplementary feed resource use for dairy cattle in the study area is shown in Table 12. According to respondents interviewed, *atella* (1st rank), salt (2nd rank), industrial by-products (3rd rank), and *atella* and combination of all supplementary feeds together (4th rank). The current result is comparable to the result of Mengistu et al. (2016), who reported that the use of these by-products for supplementary livestock feeding is justified when the forage supply is inadequate for the animals' needs in terms of either quality or quantity or when the cost of the supplementation is less than the value of increased animal production. Similarly, in Adwa and Axum, hay, crop residue, grazing, crop aftermath, and non-conventional feed like *atella* (a by-product of *katikala*) were identified as major sources of feed (Gebrekidan & Gangwar, 2015).

Table 12. Supplementary feed resource for crossbred dairy cows in the Gidole town

Types of supplementary feed	Frequency	Percent	Ranking
Atella	30	50	1st
Salt	18	30	2nd
Industrial by-products	8	13.3	3rd
Combination of all supplementary feeds together	4	6.7	4th
Total	60	100	-

3.7. Feed type and composition

Table 13 shows the principal feed types employed in the study region, as well as their chemical composition. *Atella* had the highest CP content of the feeds, followed by elephant grass, Guatemala grass, and *enset*. The NDF concentration of feed was greater in Guatemala, *teff* straw, *desho* grass, and elephant grass. The CP levels of feedstuffs were greater in *atella*, elephant grass, Guatemala grass, *desho* grass, *enset* stem and root, and teff straw. This result

suggests that *atella* has the most metabolized energy of the others, followed by elephant grass, and *teff* straw has the lowest CP of the others from the diet supplemented with dairy cows in the study area.

Feeds that have high metabolic energy are important for the development of rumen for younger animals and the increment of production in any activity of the dairy cattle. The current result of the study area is comparable with the result of Kassu (2016), who reported that the major feed types commonly used in the study area and their chemical composition were higher for *atella* in the Bona Zuria district of Sidama Zone, southern Ethiopia. Pandev & Voskuil (2011) have recommended a daily dry matter (DM) intake of 3.6 to 4% of body weight for milking cows. They further suggest that 0.2 to 0.3% of daily feeds are proteins. The fibrous feeding material, important for ruminant nutrition, is needed in adequate amounts between 40 and 50% of the diet for crude fiber, with 19–21% of ADF and 26–28% of NDF (Pandev & Voskuil, 2011).

Table 13. Chemical compositions of some selected feedstuffs used for dairy cattle in Gidole town

Feed type	DM %	Ash%	CP%	NDF%	ADF%	ADL%
Enset stem and root	90.02	6.74	13.15	47.48	22.13	2.88
Desho grass	92.68	5.73	9.51	63.85	40.29	5.43
Guatemala grass	91.77	3.35	15.43	79.97	46.09	7.91
Teff straw	91.07	4.39	6.34	73.18	47.05	7.42
Elephant grass	92.29	7.02	18.44	59.65	39.18	6.22
Atella	91.77	4.06	29.24	36.41	2.31	3.7

DM=Dry matter, CP=Crude protein, NDF=Nutrient detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin

4. Conclusion

This study at Gidole town, located in the Derashe special district, discovered numerous critical findings of dairy production and management. According to our observations, young people are underrepresented in urban and peri-urban dairy production. This trend may be due to financial restrictions and a lack of experience. Older adults, particularly those with higher education levels, may have more information and abilities concerning dairy cow nutrition and management practices, as well as better financial resources for acquiring dairy cows. The major feed resources in the study area include crop residues, especially *teff* straw and maize thinning, as well as crop aftermath, hay, and improved forages such as elephant grass, *desho* grass, and Guatemala grass. Non-conventional feeds like *atella* is also utilized. Despite its importance, feed availability remains a challenge in terms of both quality and quantity. To address this, we

recommend strong extension efforts focused on promoting the use of concentrate feed, developing and utilizing improved forage options, and treating crop residues to enhance their quality. The study observed a steady increase in the number of crossbreed dairy cows within households. This presents a potential opportunity for expanding medium- or large-scale dairy farms. Milk producers should explore supplementary feeds from agro-industrial byproducts to boost dairy cattle productivity. Implementing feed conservation methods, particularly hay and silage making during periods of excess feed availability, can mitigate shortages. Collaboration among experts and institutions is vital for realizing this potential.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

We are grateful for the financial assistance received from Arba Minch University in Ethiopia.

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