

Research Article

# Evaluation of Dairy Production Systems, Milk Quality and Feed Resources in Arsi-Negele, West Arsi Zone, Oromia, Ethiopia

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## Abstract

Urban and peri-urban dairy production in Ethiopia plays a crucial role in meeting the increasing milk demand of cities, with smallholder producers actively engaged in dairying. Despite their significant contribution, these systems face challenges such as low productivity of indigenous breeds, insufficient infrastructure, and limited access to feed and health services. Production levels remain inadequate to satisfy urban demand in towns like Arsi-Negele, Oromia region. The potential and constraints of urban dairy systems, as well as the quality of milk supplied to emerging collection points, have not been comprehensively documented. This study evaluated the cattle milk production systems, assessed milk quality, characterized feed resources, and identified production challenges in Arsi-Negelle town. The research involved field surveys and milk sample analyses from urban dairy farms. Data on farm practices, characteristics, feed types, and milk quality were collected through farmer interviews and observation. Results indicate that dairy farming in the study area predominantly employs a zero-grazing system, raising crossbred and indigenous cattle. Primary feed resources consisted of crop residues, atella (a local agro-industrial by-product), and other agro-industrial by-products. Milk quality showed variability, with some samples meeting acceptable compositional standards, while others revealed deficiencies in hygiene and handling. Milk composition analysis revealed an average fat content of 3.47%, protein 3.24%, solids-not-fat 9.18%, and total solids 12.65%. Statistical analysis indicated that parity and stage of lactation significantly influenced milk fat content ( $P < 0.01$ ), whereas protein, solids-not-fat, and total solids were not significantly affected. Although fat content was slightly higher in dedicated dairy farms (3.56%) than in mixed crop-livestock farms (3.50%), this difference was not statistically significant ( $P > 0.05$ ). The elevated fat content in dairy farms is likely attributable to a higher proportion of indigenous cattle genetics. Constraints limiting dairy productivity included inadequate feed supply, poor access to veterinary services, and limited availability of improved breeding stock. Despite these challenges, urban dairy systems in town have substantial potential to enhance local milk supply. Addressing feed shortages, improving animal health and genetic improvement programs, and enforcing stricter milk hygiene protocols could boost both productivity and milk marketability. Recommendations emphasize strengthening extension services on feeding, health management, and breeding; instituting quality control at milk collection points; and supporting smallholders through feed provision and technical training. Further research is essential to optimize production systems and tailor interventions toward sustainable urban dairy development.

## Keywords

Production System, Urban, Dairy Farms, Mixed Farms

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## 1. Introduction

### 1.1. Background

Urban livestock production systems are increasingly growing, largely driven by the rising demand for animal products among urban populations and the need for livelihood opportunities for the urban poor in many cities. Recognizing the unmet demand for livestock products, many urban dwellers are engaging in small-scale dairying and cattle fattening schemes [1]. According to [2] define urban and peri-urban dairy production systems as involving the production, processing, and marketing of milk and milk products within urban centers. While [3] reported on the prospects of peri-urban dairy development in Ethiopia without differentiating urban from peri-urban systems, [4] defines urban farming more broadly as the cultivation of food and non-food crops and rising of livestock within built-up areas. In many sub-Saharan African countries, rural areas face significant challenges including lack of infrastructure such as electricity and potable water, resulting in low living standards [5]. Consequently, many people migrate to urban areas seeking better living conditions. Urbanization not only increases city populations but also changes food habits, leading to higher consumption of meat and animal products including milk [5]. Commercial urban dairy production systems are emerging as a crucial part of the milk production sector in Ethiopia, contributing significantly to the supply of milk and dairy products in urban centers. According to [3], nearly all fluid milk supplied to major Ethiopian cities originates from urban and peri-urban dairy producers. The primary source of milk in the country is cattle [6]. The Central Statistical Agency [7] reported that approximately 2,591,187 tons of cattle milk was produced in 2002, with 96% from traditional rural holdings. Per capita milk consumption in Ethiopia is low, estimated at about 16 kg/year [8]. The growing urban demand for dairy products offers opportunities for smallholder producers to expand production. To meet this demand, milk production in Ethiopia must grow at least 4% per annum. However, current production is about 1.2 million tons/year, increasing annually by only 1.2% for indigenous cattle and 3.5% for improved stock [8]. Recently, milk collection units have appeared in Arsi-Negelle town, but the quality of milk supplied to these units requires assessment.

### 1.2. Statement of the Problem

Despite the rising urban demand for milk and meat, milk production remains low and insufficient to meet the increasing needs of urban populations in Ethiopia. Urban and peri-urban dairy production systems are key contributors to milk supply in major towns like Arsi-Negelle, yet the potential of these systems has not been fully explored or documented. Furthermore, the quality of milk supplied to emerging milk collection units in towns such as Arsi-Negelle is unknown.

Given the low productivity of indigenous breeds and limited growth rates in dairy production, there is a need to understand current production systems, milk quality, feed resources, and constraints to improve milk and meat production in urban settings. This study aims to fill these gaps by evaluating the cattle milk and meat production potential and identifying opportunities and challenges.

### 1.3. Objectives

#### 1.3.1. General Objective

To evaluate the cattle milk production system and potential in Arsi-Negelle town, West Arsi zone of Oromia region.

#### 1.3.2. Specific Objectives

- 1) To evaluate the existing milk production systems in Arsi-Negelle town.
- 2) To assess the milk composition, quality and adulteration.
- 3) To identify and characterize commonly used animal feeds in the study area.

## 2. Materials and Methods

### 2.1. Study Area

The study was conducted in Arsi Negele town, located in the West Arsi Zone of the Oromia region, Ethiopia. This area encompasses diverse agro-ecological zones including highland, midland, and lowland areas, with altitudes ranging from 1500 to 3800 meters above sea level. The region experiences a bimodal rainfall pattern with an annual average rainfall between 600 mm and 2700 mm. The local climate and agro-ecology support mixed crop-livestock agriculture, making it suitable for urban and peri-urban dairy farming.

### 2.2. Study Design and Sampling

A cross-sectional study design was employed to assess the dairy production systems, milk quality, and feed resources. A purposive sampling technique was used to select urban smallholder dairy farms in Arsi Negele town. The sample included a dairy farms and mixed (both dairy and beef) farming. Data were collected from a total of 127 households including 45 households of dairy farms and 82 households mixed farms.

### 2.3. Data Collection Methods

Primary data were collected using semi-structured questionnaires and direct farm observation and milk units/shops. Information gathered included livestock holding, herd and breed composition, feed resources and feeding practices,

housing conditions, waste management, milk processing, and utilization patterns. Secondary data were collected through review of relevant government reports, academic literature, and prior research studies on milk production in the West Arsi Zone and comparable agro-ecological zones.

## 2.4. Milk Sampling and Quality Analysis

Milk samples were collected during morning milking from 42 lactating cows with known parity and stage of lactation. For each cow, approximately 100 ml of fresh milk was collected in properly labeled bottles. Samples were immediately transported using ice boxes to the Dairy Laboratory of Hawassa University for analysis. Milk fat and solids-not-fat contents were measured using a lactic check device, Total solids were calculated as the sum of fat and SNF, Moisture content was calculated by subtracting TS from 100%. Milk composition data were analyzed according to farm type (dairy or farm), parity (first, second, third and fourth parity) and lactation stage (early, mid and late stage).

## 2.5. Milk Adulteration Test

To estimate the extent of milk adulteration, samples were collected weekly during the morning milking over seven consecutive weeks from Milk Unit and Milk Shop. Thirty-six milk producers delivered milk from Milk Unit and twenty milk producers delivered milk from Milk Shop. For each bulk milk delivery or single cow sample, milk density was measured using a lactometer, and temperature was recorded with a thermometer. Milk density (specific gravity) was calculated using the formula:

$$\text{SP. GR} = \frac{(LR+CF)}{1000} + 1$$

Where:

- 1) SP.GR. = Specific gravity (density) of milk
- 2) LR = Lactometer reading
- 3) CF = Correction factor based on milk temperature, following [9]

Milk density values were interpreted using [10] classification system to detect potential milk adulteration such as dilution by water or cream removal.

## 2.6. Data Analysis

Descriptive statistics were used to summarize farm characteristics, feeding practices, and constraints. Analysis of variance and other relevant statistical tests were employed to analyze differences in milk quality parameters across farm types and production factors. Significance was accepted at  $P < 0.05$ .

# 3. Result and Discussion

## 3.1. Livestock Holding

The average livestock holding per household was  $9.49 \pm 0.56$  heads. Households in dairy farms had an average of  $8.95 \pm 0.75$  heads, while those in mixed farms had  $10.16 \pm 0.59$  heads. Cattle being the most important animal, constituted on average 80.4% of the total livestock number. The proportion of cattle in the study area was higher than that reported for Debre-Berhan area, in which cattle constituted 63% of all the animals [11].

On average, each farmer owned 7.13 and 8.11 cattle in dairy and mixed farms, respectively. These cattle holdings are comparable to smallholder reports from Holeta, Selale, and Debre-Zeit [12] and an average cattle number 7.6 cattle per household documented in southern Ethiopia [13].

**Table 1.** Livestock holding and composition per household.

|           | Dairy farm      | Mixed farm       | Overall         |
|-----------|-----------------|------------------|-----------------|
| Variable  | Mean $\pm$ SE   | Mean $\pm$ SE    | Mean $\pm$ SE   |
|           | N=45            | N=82             | N=150           |
| Livestock | $8.95 \pm 0.75$ | $10.16 \pm 0.59$ | $9.49 \pm 0.56$ |
| Cattle    | $7.13 \pm 0.57$ | $8.11 \pm 0.48$  | $7.63 \pm 0.50$ |
| Sheep     | $1.27 \pm 0.31$ | $1.30 \pm 0.22$  | $1.27 \pm 0.17$ |
| Goats     | $0.04 \pm 0.04$ | $0.06 \pm 0.05$  | $0.05 \pm 0.03$ |
| Donkey    | $0.38 \pm 0.08$ | $0.32 \pm 0.07$  | $0.29 \pm 0.05$ |
| Horses    | $0.13 \pm 0.08$ | $0.33 \pm 0.10$  | $0.25 \pm 0.06$ |

### 3.2. Cattle Herd and Breed Composition

A total of 1137 heads of cattle were raised by all the interviewed households. Of these, 37.4% were cows, with the proportion of local, crossbred and high-grade cows being 13.7%, 6.1% and 17.6%, respectively.

The average number of cattle per household was higher than the 6.85 heads reported in Hawassa [5], while the proportion of cows was comparable to that reported in Hawassa

(37.2%) but lower than the national average of 42% and the 50% reported in the urban and peri-urban areas of the Addis Ababa milk shed [15]. Out of the total cattle, 28.2% and 57.7% were owned by dairy and mixed farms, respectively. The higher number of cattle in mixed farms reflects a larger sample of farmers included in that category. Dairy farms had a higher number of grade cattle compared to mixed farms, likely due to better management options supported by the high demand and reliable market for milk.

**Table 2.** Cattle herd and breed composition.

| Composition | Dairy farm |             | Mixed farm |             | Total |             |
|-------------|------------|-------------|------------|-------------|-------|-------------|
|             | N          | Mean (SE)   | N          | Mean (SE)   | N     | Mean (SE)   |
| Local breed |            |             |            |             |       |             |
| Cow         | 38         | 0.84 ± 0.18 | 80         | 0.98 ± 0.11 | 116   | 1.04 ± 0.10 |
| Bull        | 4          | 0.09 ± 0.06 | 23         | 0.28 ± 0.08 | 27    | 0.68 ± 0.42 |
| Heifers     | 6          | 0.13 ± 0.08 | 11         | 0.13 ± 0.04 | 17    | 0.13 ± 0.03 |
| Calves (M)  | 1          | 0.02 ± 0.02 | 19         | 0.23 ± 0.06 | 20    | 0.16 ± 0.04 |
| Calves (F)  | 4          | 0.09 ± 0.06 | 7          | 0.09 ± 0.04 | 11    | 0.09 ± 0.03 |
| Oxen        | 8          | 0.18 ± 0.08 | 164        | 2.00 ± 0.21 | 172   | 1.32 ± 0.14 |
| Crossbreed  |            |             |            |             |       |             |
| Cow         | 26         | 0.58 ± 0.15 | 37         | 0.45 ± 0.10 | 63    | 0.46 ± 0.07 |
| Bull        | 11         | 0.02 ± 0.02 | 20         | 0.24 ± 0.07 | 33    | 0.15 ± 0.04 |
| Heifers     | 10         | 0.22 ± 0.08 | 13         | 0.16 ± 0.06 | 23    | 0.15 ± 0.04 |
| Calves (M)  | 9          | 0.29 ± 0.09 | 11         | 0.13 ± 0.04 | 20    | 0.17 ± 0.04 |
| Calves (F)  | 10         | 0.22 ± 0.08 | 9          | 0.11 ± 0.04 | 19    | 0.13 ± 0.03 |
| Oxen        | 3          | 0.07 ± 0.05 | 5          | 0.06 ± 0.04 | 8     | 0.06 ± 0.03 |
| High-grade  |            |             |            |             |       |             |
| Cow         | 197        | 4.38 ± 0.16 | 115        | 1.40 ± 0.20 | 312   | 1.33 ± 0.15 |
| Bull        | 21         | 0.47 ± 0.13 | 21         | 0.26 ± 0.06 | 42    | 0.28 ± 0.05 |
| Heifers     | 52         | 1.16 ± 0.28 | 40         | 0.49 ± 0.10 | 92    | 0.61 ± 0.11 |
| Calves (M)  | 20         | 0.44 ± 0.11 | 42         | 0.51 ± 0.12 | 62    | 0.41 ± 0.08 |
| Calves (F)  | 15         | 0.33 ± 0.10 | 29         | 0.35 ± 0.08 | 44    | 0.29 ± 0.05 |
| Oxen        | 4          | ± 0.05      | 10         | 0.12 ± 0.05 | 14    | 0.09 ± 0.03 |

### 3.3. Feed Resources and Management

The major basal diets around the study area consist of crop residues and atela, a by-product of home-distilled alcohol. Wheat straw and atela are used as major feeds in all visited

farms, supplemented by wheat bran and linseed cake in 27.3% and 29.3%, respectively. This finding differs from that of [16], who reported grass hay as a major component of the diet. About 35.6% of dairy farms and 28.1% of mixed farms use wheat bran, whereas 26.1% of dairy farms and 34.2% of mixed farms use linseed cake as supplement for milking cows.

**Table 3.** Feed source patterns by farm type.

| Feed Source   | Dairy Farms (%) | Mixed Farms (%) | Total (%) |
|---------------|-----------------|-----------------|-----------|
| Wheat Straw   |                 |                 |           |
| Home Produced | 20              | 32.9            | 26.7      |
| Purchased     | 80              | 61.0            | 69.3      |
| Both Sources  | 0               | 6.1             | 4.0       |
| Atela         |                 |                 |           |
| Home Produced | 60              | 82.9            | 77.3      |
| Purchased     | 35.6            | 8.54            | 16.0      |
| Both Sources  | 4.4             | 8.54            | 6.7       |

### 3.4. Sources of Feed

The sources of cattle feed in the study area include home-produced, purchased and a combination of both. More than two-thirds of the farms purchase wheat straw from the market, while about one-fourth rely on their own production, and 4% use a combination of both sources. Conversely, 77.3% of farms obtain atela from home production, 16% purchased and 6% use both methods. Specifically, dairy farms acquire about 20% of their wheat straw from home production and 80% from purchases. In mixed farms, wheat straw sources are about 32.9% home-produced, 61% purchased and 6.1% from both sources. Regarding atela, dairy farms obtain about 60% from home production, 35.6% purchased and 4.4% from both. Mixed farms source of atela about 82.93% from home production, and 8.54% from purchased and 8.53% from both sources. The study revealed that 80.32% of respondents produce atela at home. The dependence on wheat straw among farms is attributed not to its superior quality, but rather to its abundant availability in the study area. Wheat straw is typically purchased immediately after wheat grain harvest and stored for feeding cattle throughout the year. In Holeta, Selale, and Debre-Zeit, farmers use atela primarily as a supplement [12]. However, in the present study area, atela serves as a major feed source. Feed shortages occur nearly year-round, except for a short period following crop harvest. During the rainy season, wheat straw prices almost double compared to the dry season, prompting farmers to store feed during the dry season to mitigate cost fluctuations. Other crop residues are insufficiently available near the town. Additionally, natural pasture and conserved hay are inadequate throughout the year due to limited grazing areas, as most land is allocated to crop production.

### 3.5. Feeding Practices

All farms practice a zero-grazing feeding system, where animals are continuously kept in the house or compound.

They are provided with basal feeds primarily wheat straw and atela and supplemented with concentrates to enhance milk yield. However, concentrates such as linseed cake and wheat bran are expensive, and roughages available are of poor quality and insufficient to meet the nutritional needs of all farms. Daily feed provision is mainly determined by the availability of feed rather than the actual daily nutritional requirements of the animals. Most farms use group feeding, in which feed is given collectively to all animals without accounting for their individual production levels. As a result, farmers are unable to track the exact amount of feed each animal receives. This practice can lead to suboptimal performance, especially among lactating cows, highlighting the need to tailor feeding based on animal weight and production level. In all farms, wheat straw and atela are mixed and fed to animals three times daily in the morning, at mid-day, and in the evening. When atela is insufficient, linseed cake is used as a substitute. The linseed cake is mixed with water and kept overnight, allowing it to thicken and increase in volume before being added to the atela. Individual feeding systems are more commonly practiced in dairy and mixed farms. However, feeding methods depend on farm type and more on the willingness of animals to feed together. About 51% of dairy farms and 52% of mixed farms use individual feeding, while 38% of dairy farms and 32% of mixed farms practice group feeding. The remaining farms use a combination of both feeding systems. Feeding frequency is influenced by the availability of atela. In dairy farms, about 87% feed their animals three times a day, while 13% feed twice daily. In mixed farms, 2% practice feeding four times a day. The amount of feed provided is dependent on the availability of wheat straw and atela. The overall mean use of wheat straw across all farms is  $2.6 \pm 1.7$  kg per animal per day. Dairy farms use a mean of  $1.8 \pm 1.1$  kg, and mixed farms use  $2.6 \pm 1.6$  kg per animal per day of straw. The overall mean daily atela use is  $28.1 \pm 17.7$  liters per animal, with dairy farms averaging  $28.1 \pm 20.6$  liters and mixed farms  $29.7 \pm 16.5$  liters per animal per day.

### 3.6. Water Source and Drinking Frequency

Water consumption by livestock depends on factors such as food consumption, the physiological state of the animal and ambient temperature. Indigenous breeds tend to drink less water compared to exotic breeds, as they are better adapted to hot environments and exhibit lower body water turnover. Ensuring that livestock has adequate access to clean water is crucial for their health and productivity. All dairy farms and 97.56% of mixed farms obtain their water supply from pipe water. The remaining 2.44% of mixed farms rely on river water as their water source. Comparatively, in Hawassa, 61.7% of farms use piped water, while 26.7% depend on open wells [5]. About 98% of households provide clean water to their animals, whereas 2% reported using river water as their water source.

**Table 4.** Watering frequency of cattle.

| Watering Frequency    | Dairy Farms (%) | Mixed Farms (%) |
|-----------------------|-----------------|-----------------|
| Freely available      | 12.70           | 31.43           |
| Once every two days   | 15.87           | 14.29           |
| Once every three days | 9.52            | 11.43           |
| Once per week         | 14.29           | 5.71            |
| No watering provided  | 48.62           | 37.14           |

Farms for the majority of producers, water shortage were not a significant issue except during interruptions of the public water supply. Water consumption frequency varied among farms and was generally influenced by water availability. In 48.6% of dairy farms and 37.1% of mixed farms, there was no need to provide additional water because the animals' water requirements were adequately met through feed intake, particularly atela since it contains more than 76% water. About 7.8% of households allowed their animals to drink water only once per week. This reduced drinking frequency was partly due to cattle's reluctance to drink water daily when consuming atela, which contributes substantial moisture to their diet.

### 3.7. Housing of Cattle

All visited farms have cattle barns constructed from various materials. The majority (91%) of the farms have separate cattle barns, while about 9% of the farms keep their cattle in the same room as the family house. In dairy farms, about 96% of cattle are housed in separate cattle houses, whereas in mixed farms, around 93% have separate housing for cattle. Comparatively, in Holeta, 79% of farmers keep their cattle in open barns, 10% use sheltered barns, and 11% utilize both types of barns [17]. Barn construction typically involves wooden poles from eucalyptus trees as structural supports. Roofing materials vary and can include corrugated iron sheets,

hard plastic sheets, and grass hay. Walls are made from wood, sometimes plastered with mud, or wooden without plastering. Floors are primarily earthen but can also be constructed with stone or concrete. Management practices differ among households within the same area, influenced by the literacy and economic status of farm owners. The majority of household heads in the study area are literate, with many having attained higher education. Better husbandry and barn management practices tend to be observed among younger farmers with relatively higher education levels. Regarding barn facilities, 88% of farms have feed troughs, while water troughs are rare because water is often supplied through feed. For comparison, in Holeta, 60% of farms have feed troughs, 3.3% have both feed and water troughs, and 36.7% lack such facilities [17]. Similarly, in Selale, 63.3% of farms have feed troughs, 10% have both feed and water troughs, and 26.7% do not have any barn facilities [12].

### 3.8. Waste Management

Waste management is a critical issue in urban dairy farming due to the large quantities of manure produced and its environmental impact. A single cow weighing 450 kg can produce wet manure equivalent to 6% of its body weight approximately 27 kg daily [18]. This highlights the substantial amount of manure generated depending on herd size, underscoring the importance of effective waste management to maximize benefits and minimize environmental harm. In the study area, manure is typically removed twice daily, once after morning milking and again shortly after afternoon milking. Unlike farms in Holeta, where manure is removed once daily in the morning and directed either to bulk manure storage or other uses [17], farms in the present study area lack designated temporary manure storage areas. Consequently, manure disposal practices include discharging into seasonal rivers during the rainy season, spreading on cultivated land, using as fuel, or collecting and burning it within the compound. Only a few farmers have pits for manure collection during the dry season, but during the rainy season, manure is often disposed of into runoff drainage. Overall, 87.3% of farms dispose of manure into seasonal rivers, 10.7% collect and burn dried manure in the compound, and a mere 2% use manure as fertilizer. This indicates that most farms do not utilize manure effectively, and the prevalent practice of burning manure poses a potential fire hazard. The low percentage of farms using manure as fertilizer (2.4%) is similar to the 3.3% reported in Hawassa [5] but significantly lower than the 11% recorded in Holeta [17]. Most manure in the study area contributes little beyond pollution. In contrast, in Mekele, 32.1% of farms generate income by selling manure as fertilizer [19], whereas no farms in the present study reported selling manure. Manure transport in the study area predominantly uses donkeys (57%) and handcarts (37%), with labor divided among hired workers (44.4%), children (30%), husbands (14%), and wives (4.7%). By comparison, in Holeta, 43% of farmers transport manure by

human back, 33% by donkey back, 8% using hired labor, and 92% rely on family members for this task [17].

### 3.9. Milking, Milk Processing, Utilization and Marketing

Milking and milk processing are important activities carried out by all interviewed farms. Hand milking is the common practice among the farmers. These activities are typically performed by female family members and hired laborers. However, men also participate in milking and processing when women are unavailable or engaged in other tasks. Crossbred and high-grade cows in early lactation are milked three times daily in the morning, midday, and evening accounting for 12.6% of cases. The majority of lower-yielding animals, including most local breeds, are milked twice daily, in the morning and evening (87.4%). Milking three times a day has also been reported in southern Ethiopia [14]. Similarly, in Hawassa, all farms milk their cows twice daily [5]. It is common practice to leave some milk to ensure calves have sufficient nourishment. About 60% of dairy farms and about half of mixed farms engage in milk processing, which generally occurs when there is surplus milk or when dairy products are preferred. Milk processing in all farm types is traditionally based on sour milk. The average souring time in the study area is 2–3 days, with an average volume of  $5.0 \pm 1.1$  liters processed at a time. The frequency of milk processing varies depending on milk production levels and the purpose of keeping dairy cows. In mixed farms, milk used for processing may come from a single cow or multiple milking cows. In dairy farms, processed milk typically accumulates from several milking cows. Each household converts the accumulated milk into various products. Butter is the primary product, produced by 96.3% of dairy farms and 100% of mixed farms. Buttermilk is the second most common product, made by about two-thirds of dairy farms and three-fourths of mixed farms. Cottage cheese is the third major product, produced by 74.1% of dairy farms and 40% of mixed farms. The most commonly used milking equipment is plastic buckets, used by 89.8% of respondents. Other equipment includes grass-made containers (3.2%) and nickel materials (10.8%). For churning, clay pots are predominantly used (96.7%), with a small number of respondents and the milk unit employing improved technology (3.28%) when milk is not sold. Similarly, in the Borana area of southern Ethiopia, clay pots and bottle gourds are the traditional containers most commonly used for souring and churning milk [12].

In Arsi-Negelle town, milk produced on farms is used for home consumption, sold as fresh milk, or processed into local dairy products, which are either consumed at home or sold in the local market. Only farms with crossbred and high-grade cows sell fresh milk. Farms with exclusively local breeds primarily produce milk for home consumption but occasionally sell surplus processed dairy products locally. The amount of milk produced and sold varies depending on farm type:

Dairy farms produce an average of 20.7 liters of milk per day, selling approximately 18.3 liters daily. Mixed farms produce about 18.3 liters daily, selling an average of 17.9 liters. The proportions of milk sold, consumed at home, and processed are similar across both dairy and mixed farms. In terms of sales, 34 dairy farms and 65 mixed farms sold milk, while 11 dairy farms and 17 mixed farms did not. Average daily milk consumption per household was 2.2 liters in both dairy and mixed farms. Regarding household consumption, priority for milk use was given to all family members in over three-fourths of dairy farms and about two-thirds of mixed farms. In 13.3% of dairy farms and 24.7% of mixed farms, children were given priority. Most adults (97.64%) consumed milk with coffee, while a few drank it according to personal preference. Milk sales outlets include individual buyers or consumers, hotels and cafeterias, the Milk Unit, retailers (Almi Milk), Milk Shop, and sales through farm-owned shops. Most milk sales occur on a contract basis for cash, with dairy farm owners' negotiating price and quantity with individual buyers. Milk is generally supplied daily, with payments made monthly or at the end of the month. Key factors influencing outlet choice are convenience and pricing: Cafeterias and hotels are popular outlets because they are located throughout the town or near farms. Retailers (Almi milk) operate three to four milk collection centers in town, supply concentrate feed to producers, and offer better prices, making them a preferred buyer. Almi milk collects morning and afternoon milk from Arsi-Negelle producers for distribution in Hawassa. The Milk unit pays a fixed price per liter and retails milk through its own shop, collecting milk from individual farms. Bereket milk shop operates its own dairy farm producing milk three times daily and collects milk from other farms for further processing of products such as skim milk, cottage cheese, butter, and buttermilk. Midday milk is typically sold to cafeterias, as other outlets often run out of milk at that time. Buttermilk is the most widely marketed processed product after fresh milk. It is sold by 57.8% of dairy farms and 48.8% of mixed farms. Most butter, cottage cheese, and some buttermilk produced are primarily consumed by the producing families at home.

**Table 5.** Milk Market Outlet Distribution.

| Milk Market Outlet   | Dairy Farms |       | Mixed Farms |       | Total Farms |       |
|----------------------|-------------|-------|-------------|-------|-------------|-------|
|                      | N=34        | %     | N=65        | %     | N=99        | %     |
| Cafeteria/Hotel      | 18          | 52.94 | 27          | 41.54 | 45          | 45.45 |
| Milk Unit            | 3           | 8.82  | 11          | 16.92 | 14          | 14.14 |
| Individual Consumers | 5           | 14.71 | 10          | 15.38 | 15          | 15.15 |
| Milk Sellers (Almi)  | 6           | 17.65 | 14          | 21.54 | 20          | 20.20 |
| Milk Shop            | 1           | 2.94  | 1           | 1.54  | 2           | 2.02  |

### 3.10. Milk Composition and Adlteration

The overall mean values for whole milk in the study area were fat content at  $3.47 \pm 0.05\%$ , protein at  $3.24 \pm 0.01\%$ , solid-not-fat (SNF) at  $9.18 \pm 0.02\%$ , total solids (TS) at  $12.65 \pm 0.04\%$ , and moisture content at  $87.35\%$ . Statistical analysis revealed that both parity and stage of lactation had a highly significant effect ( $P < 0.01$ ) on the fat content of milk. However, these factors did not significantly affect the protein, SNF,

or TS percentages. When milk composition was compared by farm type, the average fat content was slightly higher in dairy farms ( $3.56 \pm 0.10\%$ ) than in mixed farms ( $3.50 \pm 0.08\%$ ). Nevertheless, analysis of variance showed that farm type did not have a significant effect ( $P > 0.05$ ) on fat, protein, total solids, or SNF percentages. The relatively higher fat content observed in dairy farms may be attributable to a greater proportion of cows with indigenous genetics compared to mixed farms, which tend to have more improved breeds.

**Table 6.** LSM and SE of the factors affecting milk fat%, protein, TS and SNF.

| Factors          | N  | Fat%                     | Protein%                 | TS                        | SNF                      |
|------------------|----|--------------------------|--------------------------|---------------------------|--------------------------|
|                  |    | LSM (S.E.)               | LSM (S.E.)               | LSM (S.E.)                | LSM (S.E.)               |
| Parity           |    |                          |                          |                           |                          |
| First            | 12 | 3.71 <sup>a</sup> ± 0.07 | 3.21 <sup>a</sup> ± 0.03 | 12.90 <sup>a</sup> ± 0.05 | 9.19 <sup>a</sup> ± 0.03 |
| Second           | 10 | 3.66 <sup>a</sup> ± 0.09 | 3.24 <sup>a</sup> ± 0.08 | 12.90 <sup>a</sup> ± 0.05 | 9.18 <sup>a</sup> ± 0.02 |
| Third            | 9  | 3.38 <sup>b</sup> ± 0.10 | 3.25 <sup>a</sup> ± 0.02 | 12.84 <sup>a</sup> ± 0.04 | 9.17 <sup>a</sup> ± 0.08 |
| Fourth           | 11 | 3.08 <sup>c</sup> ± 0.08 | 3.27 <sup>a</sup> ± 0.03 | 12.25 <sup>a</sup> ± 0.06 | 9.17 <sup>a</sup> ± 0.05 |
| Lactation period |    |                          |                          |                           |                          |
| Early            | 12 | 3.62 <sup>a</sup> ± 0.09 | 3.25 <sup>a</sup> ± 0.01 | 12.77 <sup>a</sup> ± 0.08 | 9.16 <sup>a</sup> ± 0.03 |
| Mid              | 16 | 3.24 <sup>b</sup> ± 0.09 | 3.26 <sup>a</sup> ± 0.02 | 12.47 <sup>a</sup> ± 0.09 | 9.23 <sup>a</sup> ± 0.05 |
| Late             | 14 | 3.56 <sup>a</sup> ± 0.07 | 3.21 <sup>a</sup> ± 0.03 | 12.70 <sup>a</sup> ± 0.07 | 9.14 <sup>a</sup> ± 0.04 |
| Farm type        |    |                          |                          |                           |                          |
| Dairy farm       | 17 | 3.56 <sup>a</sup> ± 0.10 | 3.21 <sup>a</sup> ± 0.02 | 12.67 <sup>a</sup> ± 0.10 | 9.12 <sup>a</sup> ± 0.04 |
| Mixed farm       | 25 | 3.50 <sup>a</sup> ± 0.08 | 3.26 <sup>a</sup> ± 0.02 | 12.69 <sup>a</sup> ± 0.06 | 9.19 <sup>a</sup> ± 0.03 |
| Overall mean     | 42 | 3.47 ± 0.05              | 3.24 ± 0.01              | 12.65 ± 0.10              | 9.18 ± 0.02              |
| R <sup>2</sup>   |    | 0.60                     | 0.57                     | 0.56                      | 0.42                     |
| C.V.%            |    | 8.86                     | 2.4                      | 1.62                      | 6.44                     |

The fat content of whole milk generally declines with increasing parity (number of calving), showing an inverse relationship between cow age and milk fat content. Fat percentages tend to decrease from the first stage of lactation (1–3 months) to the second stage (4–6 months), then increase again in later stages, following a typical lactation curve where fat content dips after about 5 weeks post-parturition and rises toward the end of lactation. This pattern aligns with research findings indicating that both parity and stage of lactation significantly influence milk fat content. For example, fat content is higher in early and late lactation stages compared to mid-lactation, with fluctuations linked to physiological changes in the cow and energy balance during lactation. Milk yield also varies with parity, often peaking around the second parity and declining afterward, which corresponds to changes

in milk composition such as fat percentage. Regarding comparisons with other studies, the average fat content reported in your current study is lower than earlier values observed in Ethiopian highlands milk collection units, which recorded fat contents around 4.7% [20] and in Southern Ethiopia with 4.92% fat. These differences might be due to breed variations, management practices, feed quality, and stage of lactation sampled. In summary: Fat content tends to decline from early to mid-lactation and then increase again in later lactation. Parity affects milk fat, with possible decreases as cows' age. Early and late lactation stages have higher fat percentages than mid-lactation. Your study's fat content values are somewhat lower than some previous Ethiopian reports. This understanding helps in interpreting milk quality variations over lactation and across cow lifespans.

Milk density is a commonly used parameter to detect adulteration, such as the addition of water or removal of cream. Adding water lowers milk density, while the removal of cream (creaming) increases it. In the study area, the overall average milk density was  $1.028 \pm 0.006$  g/cm<sup>3</sup>. When analyzed by collection site: The milk unit recorded an average density of  $1.027 \pm 0.09$  g/cm<sup>3</sup>. The milk shop had a slightly higher average density of  $1.031 \pm 0.04$  g/cm<sup>3</sup>. Statistical analysis showed a highly significant difference ( $P < 0.01$ ) in milk density depending on the site of collection. Regarding milk quality based on lactometer readings (normal range: 1.028–1.033): At the milk unit, 61.11% (22 households) of samples were within the normal range, indicating unadulterated milk, while 38.89% (14 households) fell below 1.028, suggesting dilution. At the milk shop, all samples (100%; 20 households) had readings within the normal range, indicating consistently unadulterated milk. The relatively high incidence of diluted milk samples at the milk unit is attributed to it being a newly established operation with insufficiently trained personnel in milk quality control. In contrast, the milk Shop benefits from experienced staff responsible for maintaining milk quality standards.

## 4. Conclusions

The study reveals that livestock holding is moderately substantial, with an average of 9.49 heads per household, largely dominated by cattle comprising 80.4% of the total livestock. Dairy farms tend to hold slightly fewer livestock but a higher proportion of grade cattle compared to mixed farms, reflecting better management practices aligned with milk production goals. Feed resources mainly consist of crop residues (wheat straw) and atela, with atela playing a more prominent role than in other regions, though feed shortages and poor feed quality remain a challenge. Zero-grazing is the common feeding system, but feeding practices often lack precision, which may affect milk yield. Water supply is predominantly from piped sources, but watering frequency varies with many animals not provided additional water due to the high moisture content of atela. Housing conditions are generally adequate, with most farms providing separate cattle barns, though barn quality varies with farmer education and economic status. Waste management practices are poor, with most manure disposed into rivers or burnt, highlighting a missed opportunity for sustainable manure utilization. Milking and milk processing practices remain traditional, with hand milking by women and hired labor common. Milk is primarily consumed at home, sold fresh, or processed into butter, buttermilk, and cottage cheese, with market participation higher among farms with crossbred and high-grade cows. Milk quality, assessed through chemical composition and density, shows that parity and lactation stage significantly influence fat content, while milk adulteration appears to be more prevalent at larger milk collection units due to insufficient quality control.

## 5. Recommendations

In order to enhance dairy production and sustainability in the study area, the following actions are recommended. Encourage diversification of feed resources beyond wheat straw and atela, promote improved forage cultivation, and develop feed supplementation strategies tailored to different production levels to meet nutritional needs and enhance milk yield. Train farmers on individualized feeding strategies aligned with feed quantity and quality to animal production levels to optimize output and lactation stage, moving away from group feeding practices to optimize milk production efficiency. Improve water access and develop water management schedules to ensure all animals have regular access to clean water, especially during periods when atela alone is insufficient for hydration. Promote construction of improved barns with adequate ventilation, flooring, feed, and water troughs to improve animal welfare and productivity. Support farmer education initiatives to improve husbandry and housing management, which will benefit animal health and productivity. Introduce environmentally sound manure management systems, including designated storage areas and composting methods. Encourage manure use as organic fertilizer to improve soil fertility and reduce environmental pollution. Strengthen training and monitoring at milk collection units to reduce adulteration and ensure milk sold meets quality standards. Promote use of modern milking equipment and hygienic handling practices to safeguard milk safety. Facilitate farmers' access to diverse market outlets and support value addition through improved milk processing techniques. Encourage cooperative marketing to negotiate better prices and expand beyond local markets. Conduct longitudinal studies to track the impact of improved management practices on milk yield and quality, and assess socio-economic benefits for farming households.

## Author Contributions

Mulugeta Tesfaye is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The author declares no conflicts of interest.

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