MATHEWS

Review Article

Mathews Journal of Veterinary Science

Review on Dairy Cattle Production in Ethiopia: Review Article

Debiso Dekebo[1], Isayas Asefa Kebede[2,*]

[1]*School of Veterinary Medicine, Wolaita Sodo University, Wolaita Sodo, Ethiopia*

[2]*School of Veterinary Medicine, Ambo University, P.O. Box 19, Guder, Ethiopia*

ABSTRACT

Ethiopia has a large livestock population, and a relatively favorable climate for improved, high-yielding dairy cattle breeds. The aim of this seminar paper is to write a review on dairy production in Ethiopia. Among livestock production systems, dairy production is one of the prevalent production systems. It is generally a subsistence smallholder-based industry with relatively small and medium commercial dairy farms. Smallholder farmers represent about 85% of the population and are responsible for 98% of milk production. Productivity however is relatively low, quality feeds are difficult to obtain and support services are inadequate. Cattle are the main source of milk production and they have their own contribution to family nutrition and income generation. The use of AI involved in improving indigenous breeds through crossbreeding started over years later. The use of improved dairy cattle or hybrid cows with relatively better management purchased and conserved feed, and stall-feeding results in better performance and high profitability. The dairy sector is developing but not to the desired level of its potential mainly due to various challenges such as; high feed cost, land shortage and space limitation, feed quality, availability and cost problems as well as inadequate extension and veterinary services. A review of the dairy sector in Ethiopia indicates that there is a need to focus interventions more coherently. Development interventions should be aimed at addressing technological gaps and marketing problems. The government needs to pay attention to this sector and should make developmental interventions in the various components such as breeding, animal health, feeding, milk collection, storage, processing, and distribution.

Keywords: Cattle, Dairy, Development, Ethiopia, Production.

INTRODUCTION

Ethiopia has the largest livestock population [1] with an estimated 59.5 million cattle, 30.7 million sheep, 30.2 million goats, 8.43 million donkeys, 2.158 million horses, 0.409 million mules, and 1.2 million camels. Despite the abundance of livestock resources and the enormous potential for increasing livestock production, livestock productivity, and commercialization are poor [2].

Vol No: 07, Issue: 04

Received Date: August 31, 2023

Published Date: November 17, 2023

***Corresponding Author**

Isayas Asefa Kebede

School of Veterinary Medicine, Ambo University, P.O. Box 19, Guder, Ethiopia, Tel: +251-(09)-11-89-49-73

E-mail: isayasasefa@ambou.edu.et

Citation: Dekebo D, Kebede IA. (2023). Review on Dairy Cattle Production in Ethiopia: Review Article. Mathews J Vet Sci. 7(4):28.

Among livestock production systems, dairy production is one of the most prevalent in Ethiopia [3]. Ethiopia holds large potential for dairy development, mainly due to its suitable environment [4] and its large cattle population, which comprises 59.5 million [1]. Even though there is a large dairy cattle population and favorable climatic conditions, self-sufficiency in milk production is low. Accordingly, they contribute an average of 1.37 liters of milk yield per cow per day and annually about 3.1 billion liters [2,5].

Cattle are the main source of milk production, and they provide a significant contribution to family nutrition and money generation; however, goat and camel milk are also used in pastoralist areas of the country [5,6]. With strong global expansion resulting from the increasing number of customers in developing nations, the dairy industry and market have altered dramatically [7]. Milk is generally referred to as a full nutritious diet because it contains 87.2 percent water, 3.7 percent lipids, 3.5 percent protein, 4.9 percent lactose, and 0.7 percent ash. It is a valuable source of protein, fat, carbohydrates, vitamins, and minerals required by humans, especially young ones, for growth and development. However, the milk consumption rate in Ethiopia is low, at 19 lt/capital [8], compared to other countries with 50 and 90 lt/capital rates in Uganda and Kenya [6]. According to [9,10], there is no well-organized milk marketing system in Ethiopia. Considering the important prospects for smallholder income generation and employment opportunities from high-value dairy.

Dairy production in the tropics is mostly subsistence, with poor output and productivity, reliance on local breeds, and management characterized by extensive grazing and unregulated breeding. Indigenous breeds supply the majority of the milk in these systems, with local breeds accounting for nearly all of the milk produced in Ethiopia [11]. The demand for milk and milk products is increasing in developing countries, and the drivers of change in the dairy sector are demography, growing economies, underserved markets, conducive policy and an enabling environment, globalization, and market opportunities [12]. Dairy production has the highest potential to sustainably contribute to the Sustainable Development Goals (SDGs) due to its extended value chain. However, there is a need for periodic assessments of providing up-to-date information by policymakers [13].

To support the dairy sector, different interventions have been made by the government, development partners, national and international research institutions, and non-governmental organizations [14]. However, the sector has yet to fully realize its potential to produce enough milk and dairy products to meet domestic demand. As a result, the country is forced to import powdered milk and other milk products [15]. The development of the dairy sector can contribute immensely to poverty alleviation and improved nutrition in the country [16].

In Ethiopia, genetic improvement of indigenous breeds through crossbreeding and accelerated production of crossbred cows from farmers' indigenous breeds through Artificial Insemination (AI) were started following the establishment of the National Artificial Insemination Center (NAIC). However, the number of improved breeds in the country is still too small to transform the current subsistence-based smallholder dairy system into market-oriented commercial dairy production and boost milk production to meet current and predicted future domestic demands [11].

To meet the ever-increasing demand for milk, and milk products and thus contribute to economic growth, genetic improvement of the indigenous cattle has been proposed as one of the options. Genetic improvement of the indigenous cattle, basically focusing on crossbreeding, has been practised for the last five decades but with little success. Selection as an improvement tool has been given less emphasis [17]. There are basically common cattle breed raised in Ethiopia.

Borana, a popular cattle breed, is predominantly utilized and widely distributed across various countries of Africa [18]. They belong to the group of Zebu cattle (Bos indicus), with their characteristic hump and pendulous dewlap. These breed originally descended from the first introduction of zebu into Africa from West Asia. Zebu cattle are known to be better than the humpless cattle in regulating body temperature; hence with lower body water requirements. The Large East African Zebu cattle breeds, like the present-day Borana of Ethiopia, Kenya and Somalia, and the Butana and Kenana of the Sudan have very similar morphological characteristics to that of the zebu breeds of Asia [19]. The Ethiopian Borana cattle breed is well adapted to semi-arid tropical conditions. The breed has a high degree of heat tolerance, is tolerant to many of the diseases prevailing in the tropics and has the ability to survive long periods of feed and water shortage [17].

Begait cattle breed, on the other hand alternatively called Barka, is believed to be originated from Sudan and low lands

of Eritrea [20]. Begait cattle is phenotypically relatively large in size with a well-developed udder, small and stumpy horns in both male and females, long teats, a higher milk yielder and aggressive nature. The common coat colors are grey, brown, and black and white. In terms of susceptibility, they are very vulnerable to food shortage.

The other cattle breed is arsi breed. It is descended from the recent introductions of zebu into Africa from West Asia, and probably developed from a group of small shorthorn Abyssinian Zebu by the highland Oromo people [18]. Arsi cattle are mainly found in the central highlands of Ethiopia especially in Arsi, Shewa and Bale regions. They are small, short and compact. Red, with a black muzzle, is the predominant color although many animals are black, light grey or white with black spots. It is classified in to zebu cattle type [21].

Sheko breed represents the last remnants of Africa‟s original Bos taurus (humpless shorthorn) cattle which were probably the first to be domesticated in eastern Africa [22]. They are small in size either without hump or with very small hump. They have small horns and many are polled. Their color is brown or black and white. They is distantly related to Sanga cattle breeds of Ethiopia [23]. They are smaller in body size, with narrower belly and hindquarters, and shorter or no horns which made them much easier to manage. Sheko cattle have better feed conversion efficiency, longevity, and fertility good mothering ability compared to other cattle breeds in adjacent areas. Fast growth rate and possession of larger teats than the comparators were also noted as useful traits to improve milk production of the Sheko breed [24].

The major constraint for livestock production in Ethiopia is mainly feed availability, both in terms of quantity and quality [25]. Other factors are disease, poor management, inadequate animal health services, and poor performance of indigenous breeds [26]. Therefore, the objective of this paper is to review dairy production in Ethiopia.

DAIRY PRODUCTION IN ETHIOPIA

Historical Back Ground of Dairy Development in Ethiopia

The Ethiopian dairy industry was primarily traditional during the first half of the 20th century before systematic dairy production started in the early 1950s [27]. The government formed the dairy development agency (DDA) in 1971 to regulate and coordinate the collection, processing, and distribution of locally produced milk. Additionally, it aided in the establishment of dairy cooperatives to increase access to loans and technical and extension services for dairy producers [72]. Exotic dairy cattle, primarily Holstein Friesian, were distributed through government-owned large-scale production. Several nationalized dairy farms, including major dairy farms, milk producers, and small dairy farms, came together to form the dairy development enterprise (DDE). Numerous nationalized dairy farms (including large dairy farms, milk collection networks, and a processing plant) were merged in 1979 [29].

Large and small dairy farms have both been formed by private investors recently in an effort to apply market-oriented economic processes to the sector's output. This industrial farm employs graded and crossbred animals with a 279-day lactation period milk production capability of between 1120 and 1500 liters. As the main milk supplier to the urban market, this production technique is increasingly spreading in the highlands among farmers that raise both cattle and mixed-crop animals, such as those in Selale, Adaa, and Holetta [30]. Farmers must collaborate with producers who can extend the shelf life of their supply, as well as with dealers and retailers who can guarantee a capillary distribution of finished goods, in order to get access to far-off markets [31].

Overview of the Dairy Sector in Ethiopia

In Ethiopia, dairy farming is primarily a subsistence smallholder enterprise with a few small and medium commercial dairy farms. From 2003 to 2012, per capita, milk consumption in the country ranged between 32.8 and 36.5 liters [32], which is lower than Kenya's 110 liters.

Despite the large number of indigenous-breed dairy cows in the country, their milk production and productivity remain low. The annual cow milk production for the period 2015–2019 ranged from 3.06 to 3.30 billion liters (an average of 3.13 billion liters) (Table 1). This is mainly attributed to the low genetic potential of the indigenous breeds, limited availability of feed, high disease prevalence, poor animal health services, a low level of husbandry, and limited extension and research support.

The huge population of breeding female cattle provides an opportunity to improve genetics by using them as dams to produce crossbred heifers to support the country's intensified dairying [33]. However, the small number of breeding male animals and their uneven distribution across production

systems could result in the inadequacy of breeding bulls. Holstein Frisian is the most common and predominate exotic dairy cattle breed in Ethiopia. The reason behind is, its ability to adapt a wide range climatic environments and the world's known high milk production potential. Furthermore, there are no jersy breeds this much. Even if they are available, they are not adapted to environmental condition unlike holestein breed. This is why holestein cows are common in Ethiopia.

Table 1. Cattle population, proportion of female herd, dairy cows, and annual milk production in Ethiopia

Year	Cattle population (million)			Female out of total cattle population (%)	Number of dairy cows (million)	Dairy cows out of female population (%)	Annual milk yield (billion liters)
	Total	*female*	*male*				
2014/15	56.71	31.44	25.26	55.45	6.50	20.66	3.07
2015/16	57.83	32.02	25.81	55.38	6.74	21.05	3.06
2016/17	59.49	33.01	26.48	55.49	7.16	21.68	3.10
2017/18	60.39	33.02	27.37	54.68	6.66	20.17	3.10
2018/19	61.51	34.24	27.27	55.67	7.09	20.71	3.30
Average	59.19	26.44	32.75	55.33	6.83	20.85	3.13

Source: [15]

For the years 2013 to 2028, the Ethiopian dairy sector research [34] found a substantial discrepancy between annual expected milk production and demand. Furthermore, public and commercial interventions in feed supply, genetics, and animal health inputs and services would be necessary to increase milk output from a 23 percent deficit to a 20 percent surplus by 2028.

Feed Shortage

The main obstacle to the dairy production system is a lack of both quality and quantity of feed. In order to increase dairy output, roughage, and concentrate feeds are either too expensive or not available in enough quantity and quality [35]. According to [36], the most significant barrier to improving dairying is the lack of financing for feed, which is likely to have the greatest impact on the prospective milk output of cows with good milk production ability. In both mixed and urban production systems, a sizable portion of dairy producers cited shortages and high feed prices as their top issues [13].

A seasonal variety in availability and the high cost of feeds are problems that are strongly stressed by about 55 and 73% of farmers in mixed crop-livestock and urban systems, respectively. Better feeding is essential to maintaining an environment that is conducive to animal growth, and feed supplements encourage increased milk output. Because of the unpredictable weather, feed, which is often made of hay and grass, is either not available in sufficient amounts or, when it is, it is of poor nutritional quality [13]. For the dairy industry, feed is a barrier that causes insufficiency, usually in seasonal terms, poor quality, and affordability (excessively high feed costs, especially for concentrates). According to [37], the feed shortage mostly happens in the dry season of the year. The total amount of feed produced in most smallholder farms is far less than the needs of animals kept, and these cascades to the national level [15].

Feeds can be classified according to some of their general properties. The classification used hears is typical of that used in the feed industry. Feedstuffs can be classified as either concentrates or roughages [38]. Roughages are bulky materials which have high fiber content and a low nutrient density. Hay, pasture, silage, straw and cottonseed hulls are examples of roughage. Natural grazing land is a predominant feed source for livestock in Ethiopia. Crop-residue and agro-industrial by-products represent a large proportion of feed resource in mixed crop-livestock system. Reliance on a crop residue for animal feed is ever-increasing or more land is cropped to feed the fast-growing human population [39]. Cereal grains (barley, corn, sorghum, rice, wheat) are the typical "high energy" feeds for dairy cows, but they are low in protein. Rolled or cracked cereal grains are excellent sources of readily fermentable carbohydrates (starch) which

increase the concentration of energy when included in the diet. Forage crops are commonly grown plants for feeding dairy cattle in Ethiopia. This is prepared with oats and vetch mixtures, fodder beet, elephant grass mixed with siratro and desmodium species, rhodes/ lucerne mixture, hedgerows of sesbania, Leucaena and tree-lucerne being common ones [40].

Table 2. Feed source and their chemical composition for dairy cows

Types of feed	Chemical Component				
	Dry matter	Ash	Organic matter	Crude protein	Neutral detergent fiber
Grass hay	92.35	8.84	95.22	9.41	67.98
Peanut meal	90.5	6.4	93.6	48.07	30.99
Soybean	90.43	6.64	96.36	46.97	30.54
Maize	90	5.46	94.54	8.41	9.39
Wheat bran	89.88	6.21	93.79	13.14	46.45
Corn silage	34.9	4.78	94.71	8.12	44.76
Atella	13.23	6	94	15.9	40.6
Green grass	30.49	12.3	87.7	13.2	67.9

Source: [41]

Dairy Sector Improvement

AI has been used to improve indigenous breeds through crossbreeding for 40 years. However, improved breeds (crossbred and exotic cows) account for only 2.34 percent of the overall cattle population [11]. This number is far too low to bring about the expected growth and transformation of the dairy sector. Different business models have been used by developing countries to change their dairy industries. The Anand cooperative dairy model, for example, has been utilized in India, the dairy park model in China, and the contract farming model in other Asian nations. Ethiopia could also adopt a similar approach to transform its dairy sector [15]. The government, development partners, national and international research institutions, and non-governmental organizations have been implementing initiatives such as the Building Rural Income through Inclusive Dairy Business Growth in Ethiopia project and the Enhancing Dairy Sector Growth in Ethiopia project to support dairy sector development in Ethiopia [42].

To fully express their genetic potential and bring maximum benefit to farmers, improved livestock breeds need to be fed adequately using good-quality feeds. Therefore, farmers' education should focus on feed and feeding as one of the components during the scale-up of improved dairy technologies. In this regard, the government policy has been set to improve the problem of feed quality by jointly working with the International Livestock Research Institute (ILRI), the Ministry of Agriculture (MoA), and Agricultural Transformation Agency (ATA), and the Indian Council of Agricultural Research (ICAR) which has been focused to adopt a feed database tool from India into Ethiopian conditions to guide evidence-based decisions and to guide investment. However, the successful application of this tool requires reliable district-level data on land use, cropping patterns, and livestock numbers, which is lacking at present [15].

Dairy Production System in Ethiopia

Since the prehistoric period, dairy production has been a significant activity in Ethiopia [43]. Smallholder mixed farming is the major agricultural production system in the highlands, with crop and livestock husbandry often done within the same management unit. Among the systems, the dairy production system is the most efficient because it converts large quantities of roughage, the most abundant feed in the tropics, to milk, the most nutritious food [44]. Based on their location, rural, peri-urban, and urban productions are the three main dairy production system classifications in Ethiopia [45].

Traditional dairy farming in Ethiopia provides the majority of the country's milk, with cattle kept primarily for drought resistance rather than for their ability to produce milk, with butter production prioritized above fluid milk [46]. Since

the rural system is not market-oriented, the majority of the milk produced there is kept for domestic use. Demand for milk from the household and its neighbours determine the amount of surplus milk. According to [28], this system's milk production is characterized by poor yield and seasonal availability. Smallholders in rural areas produce 97 percent of the nation's milk, which is then distributed to consumers. It is highly reliant on the low productivity of the indigenous Zebu cattle breeds, which can produce 400–680 litters of milk per cow per lactation period [47]. Pastoralists, agro-pastoralists, and mixed crop-livestock producers are grouped under the rural dairy production system [48].

The pastoral milk production system is commonly practiced in the lowland parts of Ethiopia, where livelihoods are dependent on their animals. The erratic nature of the rainfall pattern and other associated reasons result in shortages of feed and milk production, so milk per unit area is low and highly seasonal. The primary use of fresh whole milk is for home consumption, followed by sale to urban centers and fermentation to process it into butter [49]. The remaining milk will be stored to be fermented for a longer term, for up to 30 to 60 days, [50].

In the pastoral area, the agro-pastoral system has similar but gradually sedentary ecological characteristics and animal types. In comparison to the previous system, the new system gives more thought to the milk market and its access to additional inputs such as animal health services and supplementary feed made from industrial byproducts, as well as the development of forage for calves and milking cows near newly started farmland [49]. The other system of dairy production is the mixed crop-livestock production system, in which milk production is an integral part of the production system of small-scale and non-commercial subsistence farms, which account for 83.9 percent of the population and produce 98 percent of total milk and 75 percent of commercial, liquid milk [50,51]. Indigenous stocks are the most common animals kept in this system.

Urban dairy production techniques are used in most Ethiopian towns with little or no land resources for milk production and sale [3]. In comparison to other dairy production systems, it is the most market-oriented [52]. Cattle are kept in new shelters fashioned from locally sourced materials [53]. The main feed resources employed in the urban dairy cattle production system are concentrates, roughages, and non-conventional feeds. Under the intensive management system, urban dairy cattle production systems have better access to inputs and services provided by the public and private sectors as compared to other dairy cattle production systems [3,7]. They also have access to animal health services and use more intensive systems. But milk supply is low due to the small number of dairy cattle kept under this system [7].

The bulk of peri-urban dairy production systems are situated outside of cities, where access to urban centers with a strong demand for dairy animal products is easier [46]. The majority of dairy cattle farmers feed hybrid cows extra concentrates. The majority of the improved dairy cattle are used in this dairy farming technique. The development of this production system is taking place in areas with high population densities and decreasing agricultural land owing to urbanization around major cities like Addis Abeba. It has a variety of animal breeds on small to medium-sized farms, from 50% crosses to high-grade Friesian. Most of the improved dairy stock in the nation is owned by this industry [6]. Hay, both made at home and bought, serves as the primary source of nutrition. This production system is now expanding in the highlands among mixed crop-livestock farmers, such as those found in Selale and Holetta, and serves as the major milk supplier to the urban market [56].

Generally, urban and peri-urban dairy cattle production systems use improved dairy cattle or hybrid cows with relatively better management, purchased and conserved feed, and stall feeding. As a result, cows show better performance and are highly profitable as compared to other systems [46]. According to [57], the average number of hybrid dairy cattle was greater in urban areas than in peri-urban dairy cattle production systems [58]. In addition to this, dairying practices in urban and peri-urban areas increased income. Butter and cottage cheese are dairy products that are produced and used as sources of income to buy farm inputs [43].

Dairy Value Chain

Value chain is the full range of activities, which are required to bring a product or service from conception, through the intermediary phases of design, production, and delivery to the final consumers [59]. There are a number of elements that need to be considered in the value chain of a given commodity. Actors along the chain, their functions and interconnections, chain governance systems, and player roles are among the most important. The impact of updating products, services, and processes throughout the chain, and the distribution of

benefits among players inside the chain are all factors to be considered [59,60]. The dairy value chain could be mapped based on core processes in the value chain, the main actors involved in the process and their functions, the flow of product and its volume [61].

The success of dairy development depends on how well the value chain is supported or enabled and how well the challenges at each node of the value chain are sustainably resolved [56]. Interventions by different actors in the dairy value chain target a specific part of the chain. Thus, it is important to critically assess the whole dairy value chain, identify the challenges, exploit the opportunities, and focus on the roles and responsibilities of different actors in the value chain and the modalities of engagement of different actors based on their comparative advantages [62].

The act of adding value(s) to a product to provide form, place, and time utility that increases the customer value offered by a product or service is known as value addition. The global market's rising tendency for processed agricultural goods provides chances for smallholder farmers in developing nations to gain by integrating their activities into value chains through vertical and horizontal linkages [63].

Dairy value chain actors

Chain actors are people who participate in the input supply, production, processing, marketing, and consumption of a certain dairy product. Numerous public and private-sector entities are involved in and assist the development of the dairy value chain because of the chain's complexity [15]. The key players in the dairy value chain who play a variety of important roles at different stages of the dairy value chain and so contribute to the development of the dairy industry in the nation are listed in (Table 2).

Table 3. Major actors and their involvement in the dairy value chain

Actor category	Actors	Involvement in the dairy value chain
Input suppliers	Improved breeds, breeding bull, and semen producers and providers	The Holeta Dairy Bull Dam Center produces elite crossbreed bulls and sends them to NAIC, which in turn uses them to produce semen. National Artificial Insemination Center (NAIC) distributes selected crossbred and local (Borana, Begait and Fogera) bulls to bull stations managed by individual farmers. NAIC supplies semen to its 16 (currently 9 are functional) sub-centers distributed in five regions.
	Knowledge and skill providers	A number of institutions such as agricultural universities and colleges, international research institutions such as the International Livestock Research Institute(ILRI), Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) provide long and short-term technical, theoretical, and practical pieces of training to various actors (producers, processors, development agents)
Direct actors	Milk producers	Small-scale producers (account for about 97% of the country's annual milk production with the difference being produced by medium and large-scale urban and peri-urban dairy producers.
	Collectors and distributors	These are individual collectors of milk (milk hawkers) from producers and distribute to various consumers/retailers (cafés, restaurants, hotels),
	Retailers	Retailers towards the end of the dairy value chain play the role of linking producers with consumers.
	Consumers	These are the final consumers sourcing dairy products from different actors from producer to retailer

Source: [64]

Constraints and Opportunities of Dairy Production in Ethiopia

In Ethiopia, there are numerous potentials for dairy production [52,65], including high demand for milk and its products, a large human population with a long history of using milk and its products, a rapid rate of migration from rural to urban areas and revenue growth, the availability of skilled manpower, the presence of research center organizations and technologies, the presence of service providers such as veterinary health and artificial insemination (AI) centers, and the creation of jobs. On the other hand, the development of the infrastructural sector, such as road access or building to connect towns with kebeles, water supply, electrification, and communication activities, would support modern dairying [66]. There are high demands for milk, milk consumption traditions in society, and the presence of people with different cultural and religious backgrounds in Ethiopia [10].

The ultimate goal of the dairy production and value chain intervention is to increase urban and peri-urban incomes by increasing the number of dairy producers earning a living and upgrading from the dairy industry through high-productivity enterprises while delivering affordable dairy

products to the market [67]. Due to its huge potential to contribute to improved revenue, employment opportunities, and food security, dairying is predicted to play a big part in the country's economy [68]. Continuous urbanization, a growing human population, increased demand for milk, income-generating opportunities, and employment prospects all present potential. Milk and its products such as fermented milk (yogurt), butter, cottage cheese, butter milk, ghee, and whey are in high demand, which presents a good opportunity for dairy producers [52].

The Ethiopian dairy sector is developing but not to the desired level of its potential, mainly due to various constraints. These constraints differ among the three production systems in different locations [6]. High feed costs, land shortages and space limitations, feed quality, availability, and cost problems, as well as inadequate extension and veterinary services, were major dairy production system constraints in Ethiopia. The majority of farmers reported that a shortage of grazing land was the main problem for milk production, followed by disease and parasites in Ethiopia [69].

Environmental Stress

Concomitant with the improvement in the quality of livestock through crossbreeding, there has been an increase in the susceptibility of these animals to various diseases, including exotic ones. Simultaneously, a number of disease control programs have been initiated with the aim of reducing morbidity and mortality [70]. Efforts have been made to control diseases like rinderpest, foot and mouth disease, and anthrax. Financial constraints generally inhibit the farmers' access to organized veterinary services, and they still rely on conventional treatment methods [69].

The Ethiopian government faces budgetary constraints to carry out the extension at the farmer level. Some international donors and NGOs engage in rural development programs that include extension activities [71]. Private input supply companies do not provide technical education services in dairy production (e.g.feeding, genetics, and animal health). Effective and adequate extension services, advice on animal nutrition, and feeding management are not always available to the dairy farmer [55].

Animal Health Problem

According to [72], the loss of animals due to diseases was aggravated by a shortage of veterinary professionals, the accessibility of veterinary services, and a lack of adequate transport facilities. The existence of such poor performance by the veterinary service indicated that the regional government gave less attention to the livestock sector in general. The poor performance of veterinary services in the lowlands is the result of the government's monopolized service. Disease [3] in dairy animals also affects reproduction, milk production, milk quality, mortality, and morbidity. Morbidity and mortality associated with a disease are the major constraints that hinder the progress of the dairy sector and cause poor performance [37].

Dairy production is also influenced at varied levels due to the prevalence of various diseases and parasites, like external parasites, internal parasites, and infectious diseases [73]. The prevalence of such diseases and parasites is highly dependent on ecology and management. Besides this fact, the health extension service provided is insufficient, with a high cost of drugs and poor diagnostic services. According to [74], dystocia, retained fetal membrane, and the poor reproductive efficiency of dairy cows are primarily caused by abortion, metritis, anestrous, and uterine and vaginal prolapse.

Since the animal health care system mainly relies on veterinary interventions, many of these issues are caused by the interaction of the restrictions themselves. For instance, poorly fed animals develop low disease resistance and reproduction issues. The dairy commercial business is likewise constrained by money. As a result, creating credit service facilities is crucial for the dairy industry [13]. The shortage of diagnostic testing tools and the significant staff and talent turnover are both effects of inadequate budgets.

The problem of diseases is becoming very important with the importation of exotic breeds into the country for improved genetics and milk production. Among the diseases, mastitis is known to be prevalent in different dairy production systems in the country, incurring high economic losses. It can be presented with visible or invisible inflammatory responses of the udder. Mastitis with visible symptoms is called clinical mastitis, whereas mastitis without visible symptoms is called sub clinical mastitis [75]. Clinical mastitis is characterized by sudden onset, alterations of milk composition and appearance, decreased milk production, and the presence of the cardinal signs of inflammation in infected mammary quarters. It is readily apparent and easily detected. In contrast, no visible signs are seen either on the udder or in the milk in case of

sub-clinical mastitis, but the milk production decreases and the somatic cell count increases. It is more common and has serious impact in older lactating animals than in first lactation heifers [76]. Because of the lack of any overt manifestation, the diagnosis of sub-clinical mastitis is a challenge in dairy animal management and in veterinary practice [75].

Mastitis is caused by a wide spectrum of pathogens and, epidemiologically categorized in to contagious and environmental mastitis [77]. Contagious pathogens are those for which udders of infected cows serve as the major reservoir. They spread from cow to cow, primarily during milking, and tend to result in chronic sub-clinical infections with flare-ups of clinical episodes. The most common environmental mastitis pathogens are coliform bacteria such as E. coli, Klebsiella pneumonae and other Klebsiella species [78].Transmission of environmental mastitis pathogens may occur at any time including during milking and between milkings since they are in the environments of dairy cows. Contagious pathogens include: Staphylococcus aureus, Streptococcus agalactiae, Mycoplasma spp. and Corynebacterium bovis [79]. The cow's environment is the main source of infection for environmental mastitis causing pathogens.Environmental pathogens include E. coli, Klebsiella spp., Strept. dysgalactiae and Strept. uberis and the majority of infections caused by these pathogens are clinical and of short duration [80]. Among all the pathogens of bovine mastitis, Staph. aureus is recognized as the most common causative agent of bovine mastitis in Ethiopia [81,82]. The most common contagious pathogens are Staph. aureus and Strep. agalactiae indicating that their presence in high rate could be due to lack of effective udder hygiene and poor milkers' hygiene practice during milking cows.

Poor Input Supply

Some of the available inputs and services include dairy inputs, extension, animal health, credit, market information, and artificial intelligence. According to [36], Ethiopia's usage of AI services has not improved the reproductive performance of the country's dairy industry since there are insufficient facilities and competent AI specialists, as well as a lack of service delivery options. The difficulties encountered in providing these services are related to inefficiency, insufficiency, and low-quality products, according to [3]. Additionally, the national capacity to generate some of the inputs is lacking, and there is little private-sector participation.

The cost of importing purebred dairy breeds is high, hence the most practical entry point to commercial dairying in the country is through the use of crossbred cows. The demand for crossbred cows is increasing with the growth of the dairy sector and increasing demand for milk [83]. The main sources of crossbred heifers are from AI services provided mainly by the public, and a few private, technicians. However, AI services are not available everywhere and where available, semen from bulls that have not been appropriately selected are offered. Also, charges for AI delivery are high [84].

Animal Genetic-Related Problem

Native cattle breeds are the main source of milk and dairy products in Ethiopia. Crossbred cows are extremely rare and are mostly found in and around major metropolitan and peri-urban locations. Native cow breeds are sometimes described as versatile creatures that are raised in low-input farming systems. These animals produce little milk and have been naturally chosen for adaptive features rather than functional ones [3]. About 99% of Ethiopia's native cattle populations, which have evolved to withstand food and water shortages, disease difficulties, and severe temperatures, are genetically similar to dairy cattle. The country's biggest issue with productivity is the genetic limitations of the native cattle, which lead to low milk production. Crossbreeding has been used, and the results have been promising [35]. The lack of better breeds in the nation is a sign that modern technology tools like artificial insemination and bull service are not widely used [85]. According to a survey [86], low breed performance continues to be a major barrier for small and medium-sized businesses.

Dairy cows welfare and housing system

The level of animal welfare varies considerably among dairy herds. Producers have always been concerned about the condition of animals in their care and have tried to ensure that they are healthy and well nourished. Tradition of animal care, good welfare is seen largely as the absence of illness or injury. More recent concerns about animal welfare have focused on the pain or distress that the animals might experience as a result of widely accepted management practices, and the possibility that animals suffer as a result of being kept under apparently "unnatural" conditions [87]. People caring for the animals are naturally concerned about the addressing issues such as disease, injury, poor growth rates, and reproductive problems that are bad for the animal and also for the viability of the farm. However, many people are also concerned with

the affective (emotional) state of the animal and focus on whether the animals are suffering from unpleasant feelings, such as pain, fear, or hunger, or whether they are experiencing positive states, such as pleasure associated with play. The World Organization for Animal Health defines an animal as being in good animal welfare if it is "healthy, comfortable, well nourished, safe, able to express innate behavior, and is not suffering from unpleasant states such as pain, fear, and distress" [88].

The good health is central to good welfare is relatively uncontroversial. Measures of biological health used by veterinarians and producers generally focus on disease, injury, and reproductive problems. For example, high rates of mortality are almost always associated with a poor quality of life for the animals. Surveys continue to report high levels of mortality in milk-fed calves [89] and clearly both the calves and the producers would benefit from reduced mortality rates.

Lameness is widely regarded as a major welfare problem for dairy cows. Management factors, such as the use of concrete floors, zero grazing, and uncomfortable stalls, are important risk factors underlying the large differences between farms in the incidence of lameness [90]. Management factors, such as the use of concrete floors, zero grazing, and uncomfortable stalls, are important risk factors underlying the large differences between farms in the incidence of lameness [90]. Transition diseases result in an important economic loss for producers and are one of the most serious welfare issues affecting dairy cows. The high prevalence of infectious disease may be linked to inadequate nutrition which may also contribute to a depression of the immune system during transition [91].

The development of different housing systems in previous decades has been driven primarily by technical innovations required by changes in cow requirements, farmer demands, and societal and environmental impact (national and local). These requirements and demands differ among countries, resulting in a wide variety of dairy housing systems. Technical innovations in feeding and milking made the transition to cubicle barn possible. However, studies by [92] have shown that the prevalence of lameness and hock lesions can be high in cubicle barn on concrete flooring, including both slatted and solid floors. Therefore, farmers are searching for solutions to prevent lameness and further improve animal welfare.

Role of Artificial Insemination in Dairy Production

Artificial insemination (AI), or the use of devices to introduce sperm into the female genital tract, was the first generation of reproductive biotechnologies that could be used on cattle. It is the collection, processing, storage, and artificial introduction of male sperm into the female reproductive tract for the purpose of pregnancy [93,94]. It is the most widely utilized technology on dairy farms and is used for the production of herd replacements. It plays an important role in increasing the yielding capacity of cows and is the appropriate and cheapest way of genetic improvement [95]. The dairy industry's goal has always been to produce quality milk for the consumer market. In many countries, yield per cow has more than doubled in the last 40 years. This dramatic increase in yield per cow is due to rapid progress in genetics and management. Daughters of AI sires produce significantly more milk than those of herd bull sires, and the income from this extra milk may cover the extra costs resulting from extended calving intervals because of low heat detection. A study indicated that daughters of AI sires were producing almost 900 kg more milk per lactation than daughters of natural service bulls [96].

The indigenous Zebu breed accounts for about 98.56% of the total Ethiopian cattle population, while exotic breeds (mainly HF) and their crosses account for about 1.44% of the total cattle population [97]. The indigenous breeds have the advantages of resisting high temperatures, drought conditions, and diseases, as well as producing milk with a higher fat content compared to exotic breeds. However, indigenous breeds also have some limitations. They have a lower productivity of 403 liters compared to 2123 liters of milk per lactation for crossbreeds [98]. The Ethiopian artificial insemination (AI) sector has been found to be very limited in coverage and is estimated to cover less than 1% of all dairy animals [97,99].

Despite the well-known advantages of artificial insemination, a large number of dairy farmers all over the world still use natural service (NS) bulls to breed their cows. The main arguments allegedly justifying their choice are higher AI costs compared to those of keeping herd bulls and additional costs resulting from extended calving intervals because of low heat detection rates when AI is used. AI costs include labor, equipment, liquid nitrogen, semen, and three ratios of "services per conception" [96]. Artificial insemination requires an accurate time of insemination to ensure the best chances of conception. The whole reproductive success farm

can be reliant on the skills of inseminators, and there is room for human error. Artificial insemination is a trained skill that takes a lot of time and practice to carry out efficiently and effectively each time. Because of this, a qualified vet or animal technician will be needed, and this can be costly [100]. Other disadvantages of AI include poor conception rates due to poor heat detection, the low efficiency of AI technicians, and the dissemination of reproductive diseases [101]. High costs of collection, processing, storage, and transport of semen, as well as budget and administrative problems and the inefficiency of AI technicians are also disadvantages of AI [102].

Importance of Dairy Farming for the National Economy

All livestock currently supports and sustains the livelihoods of 80% of the rural poor. Of the total population, 35–40% of all livestock are located in GDP pastoral areas. Female cattle constitute about 55.48% of the national herd [103]. Milk and milk products contribute 63 percent of the gross value of ruminant livestock production. The GoE has been underestimating the contribution of livestock and especially milk to the agricultural gross domestic product (GDP) of the country [85].

According to [104], 12 to 14 percent of the world population (an estimated 750 to 900 million people) lives on dairy farms or within dairy farming households. Employment and income from dairy will vary between and within production systems because of differences such as feed sources, management systems, milk disposal patterns, and access to or use of technology. In Ethiopia, traditional smallholder mixed farming systems generate several times more employment but low income per unit of milk produced compared with urban and peri-urban dairy systems because of the low productivity of animals. Most women are involved in traditional milk processing and marketing [13]. The production of one million liters of milk per year on a small-scale dairy farm creates approximately 200 on-farm jobs.

Livestock, milk, and milk products play an important role in the food security status of both highland and pastoral communities. In highland areas, income earned from daily milk production is used to purchase agriculture inputs or hire labor and land, effectively increasing a household's food production potential [105]. Although the daily income earned is marginal, especially from low-milk-producing local breed animals, milk sales and livestock ownership are necessary for food security. For example, farmers without access or unwilling to join a cooperative will often contract to sell their milk to a neighbor or a local café [106]. The buyer pays monthly while receiving milk daily. This monthly cash transaction enables farmers to save small amounts of daily income for re-investment into household livelihoods or the purchase of other livestock [107].

Dairy provides important sources of vitamins and minerals, including potassium, calcium, riboflavin, and B12 [108]. These micronutrients, particularly important for infants and young children, are largely insufficient, absent, or poorly bioavailable in plant-based diets, making dairy an important and essential source of nutrition. Milk is also highly energy-dense, which is important for young children or chronically ill patients with a lack of appetite. Thus, the consumption of even small quantities of milk can markedly improve the nutritional quality and diversity of the diet [109].

CONCLUSION AND RECOMMENDATIONS

Dairy production is an important component of livestock farming, which has been essentially practiced as an important activity in Ethiopia since the ancient period. Based on their location, rural dairy production, puri-urban dairy production, and urban dairy production are the three main dairy production systems in Ethiopia. The rural system is non-market-oriented, and most of the milk produced in this system is retained for home consumption. Pastoralists, agro-pastoralists, and mixed crop-livestock producers are grouped under the rural dairy production system. Urban dairy production systems are practiced with little or no land resources for the production and sale of milk. The peri-urban dairy production systems are mainly located at the edge of the town, which has comparatively better access to urban centers in which dairy cattle products are extremely wanted. The dairy sector is developing but not to the level of its potential, mainly due to various constraints. The major constraints that cause a decline in dairy production are high feed costs, land shortages and space limitations, feed quality, availability, and cost problems, as well as inadequate extension and veterinary services. With the existing constraints, there are many opportunities, such as a large number of livestock, a favorable climate, and an emerging market opportunity for livestock that assist dairy development.

Based on the above conclusion, the following recommendations are forwarded:

- Genetic improvement of local animals has to be implemented for further development and productivity should be improved through selection and use of appropriate management.
- There must be a link between agricultural research and further investigation performed on breeding system and different production systems to improve dairy sector production and development.
- Education, training, and continuous awareness creation for the improvement of knowledge and skills of private investors, individuals, and cooperatives to involve in dairy production and to dairy owners attain an expected level of production and effective profitability.
- The government should encourage private investors, individuals, and cooperatives to be involved in dairy production and processing by providing land for dairy farms, and access to credit with appropriate control.

DECLARATIONS

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data sets developed and analyzed were included in this study.

COMPETING INTERESTS

Not applicable.

FUNDING

No funds were received for this research work.

AUTHORS' CONTRIBUTIONS

DD: Conceptualization, Investigation, Resources, Writing–Original Draft Preparation; IAK: Writing – Review & Editing, Visualization, Validation, Data Curation. All authors read and approve final version.

REFERENCES

1. Central Statistical Agency (CSA) (2016/17). Agricultural sample survey, federal democratic republic of Ethiopia report on livestock and livestock characteristics.
2. Mebrate G, Tewodros A, Dawit A. (2019). Dairy Production in Ethiopia-Existing Scenario and Constraints. Biomed J Sci & Tech Res. 16(5):12304-12309.
3. Azage T, Berhanu G, Dirk H, Berhanu B, Yoseph M. (2013). Smallholder dairy production and marketing systems in Ethiopia: experiences and opportunities for market-oriented development. IPMS (Improving Productivity and Market Success). p. 31.
4. Bereda A, Yilma Z, Nurfeta A. (2014). Dairy production system and constraints in Ezha districts of the Gurage zone, Southern Ethiopia. Global Veterinaria. 12(2):181-186.
5. Hunde D. (2018). Dairy cattle breeding program in Ethiopia: Lesson learned from case studies in the tropical countries. Academic Research Journal of Agricultural Science and Research. 6(2):97-104.
6. Kassa A. (2019). Review of performance, marketing, and milk processing of dairy cattle production system in Ethiopia. Journal of Dairy, Veterinary & Animal Research. 8(1):1-9.
7. Gezu T, Zelalem Y. (2018). Dairy Trade in Ethiopia: Current Scenario and Way Forward-Review. Dairy and Vet Sci J. 8(1):555728.
8. ATA. (2016). Promising investment opportunities in Ethiopian agribusiness. WEF Grow Africa, Ethiopia.
9. Geleti D, Hailemariam M, Mengistu A, Tolera A. (2014). Analysis of fluid milk value chains at two peri-urban sites in western oromia, Ethiopia: Current status and suggestions on how they might evolve. Global Veterinaria. 12(1):104-120.
10. Eyassu S, Reiner D. (2014). Analysis of the dairy value chain: Challenges and opportunities for dairy development in Dire Dawa, Eastern Ethiopia. Int J Agric Pol Res. 2:224-233.
11. CSA (2019). Agricultural sample survey 2018/19 report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin. pp. 588.
12. Shapiro BI, Gebru G, Desta S, Negassa A, Nigussie K, Aboset G, et al. (2017). Ethiopia livestock sector analysis. ILRI Project Report. Nairobi, Kenya: ILRI.

13. Yilma Z, Emannuelle GB, Ameha S. (2011). A review of the Ethiopian dairy sector. Ed. Rudolf Fombad, FAO Sub Regional Office for Eastern Africa (SFE), Addis Ababa.

14. Tegegne A, Gebremedhin B, Hoekstra D. (2010). Livestock input supply and service provision in Ethiopia: Challenges and opportunities for market- market-oriented development.

15. Gebreyohanes G, Yilma Z, Moyo S, Okeyo Mwai A. (2021). Dairy industry development in Ethiopia: Current status, major challenges and potential interventions for improvement. ILRI Position Paper.

16. Ahmed MA, Ehui S, Assefa Y. (2004). Dairy Development in Ethiopia. EPTD Discussion Paper 123. Washington DC, USA: International Food Policy Research Institute (IFPRI).

17. Haile A, Ayalew W, Kebede N, Dessie T, Tegegne A. (2011). Breeding strategy to improve Ethiopian Boran cattle for meat and milk production. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 26. Nairobi, Kenya, ILRI.

18. Domestic Animal Genetic Resources Information System (DAGRIS). (2006). Rege JEO, Ayalew W, Getahun E, Hanotte O, Dessie T (eds). International Livestock Research Institute, Addis Ababa, Ethiopia. Available at: http://dagris.ilri.cgiar.org

19. Loftus R, Cunningham P. (2000). Molecular genetic analysis of African zeboid populations. UK: UCL Press. pp. 251-258.

20. Zerabruk M, Vangen O, Haile M. (2007b). The status of cattle genetic resources in North Ethiopia: On-farm characterization of six major cattle breeds. Animal Genetic Resources Information, No. 40, 2007.

21. Tesfaye C, Emiru Z, Mulugeta S, Bruk Y. (1994). Livestock breed types and improvement programs in Ethiopia. National Artificial Insemination Center, Addis Ababa, Ethiopia. pp. 1-6.

22. ILRI. (2007). International Livestock Research Institute. The „big five" African vintage cows. Available at: http://www.ilri.org/ilrinews/index.php/archives/546.

23. Dadi H, Tibbo M, Takahashi Y, Nomura K, Hanada H, Amano T. (2008). Microsatellite analysis reveals high genetic diversity but low genetic structure in Ethiopian indigenous cattle populations. Anim Genet. 39(4):425-431.

24. Takele T, Workneh A, Hegde BP. (2009). Status of Ethiopian indigenous Sheko cattle breed and the need for participatory breed management plan. Eth J Anim Prod. 9(1):1-12.

25. Mengistu A, Kebede G, Feyissa F, Assefa G. (2017). Review on major feed resources in Ethiopia: Conditions, challenges, and opportunities. ARJASR. 5(3):176-185.

26. Dawit T, Ahmed S. (2013). Reproductive health problems of cows under different management systems in Kombolcha, Northeast Ethiopia. Advan Biol Res. 7(3):104-108.

27. Ahmed MA, Ehui S, Yemesrach A. (2003). Dairy development in Ethiopia. Paper presented at the success in African Agriculture Conference In: Went, IFPRI, NEPAP, CTA conference paper. No. 6.1-3, Pretoria, South Africa.

28. SNV (Netherlands Development Organization). (2008). Study on Dairy Investment.

29. Zegeye Y. (2000). DDE's Experience in Milk Collection, Processing, and Marketing: In Proceedings of the Role of Village Dairy Cooperatives in Dairy Development." Smallholder Dairy Development Project (SDDP), (MOA) Ministry of Agriculture, Addis Ababa, Ethiopia. pp. 49-58.

30. Tadesse G, Yilma Z. (2018). Dairy Trade in Ethiopia: Current scenario and way forward review. Dairy and Vet Sci J. 8(1):001-0013.

31. Desalegn SG, Eweg IR. (2018). Assessment of Performance and Improving the Role of Dairy Cooperatives in the Milk Value Chain: The Case of Degem District, North Shoa Zone, Ethiopia. Assessment. 8(9).

32. Yilma Z, Hailu Y, Wolkaro T, Eshetu M. (2017). The Ethiopian dairy value chain with a particular focus on cattle and camel milk: Current scenarios and investment opportunities. East African Journal of Sciences. 11(2):81-92.

33. Berry DP. (2021). Invited review: Beef-on-dairy—The generation of crossbred beef×dairy cattle. J Dairy Sci. 104(4):3789-3819.

34. Shapiro BI, Gebru G, Desta S, Negassa A, Nigussie K, Aboset G, et al. (2015). Ethiopia livestock master plan. ILRI Project Report. Nairobi, Kenya: ILRI.

35. Guadu T, Abebaw M. (2016). Challenges, opportunities, and prospects of dairy farming in Ethiopia: A review. World J Dairy & Food Sci. 11(1):01-09.

36. Sinishaw W. (2005). Study on semen quality and field efficiency of AI bulls kept at the National Artificial Insemination Center. Debre Zei. 53(2):135-138.

37. Ibrahim H, Ololaku E. (2000). Improving cattle for milk, meat and traction (Vol. 4). Nairobi, Kenya: ILRI (aka ILCA and ILRAD).

38. Cheeke PR. (2005). Aplied Animal Nutrition: Feeds and Feeding. (3rd ed). Oregon State University: PEARSON prentice Hall. pp. 24-261.

39. Alemu Y. (2009). Nutrition and feeding of Sheep and Goat. In: Ethiopian sheep and Goat Production Improvement Program. pp 106-159.

40. Alemayehu M. (2006). Country Pasture/Forage Resource Profiles: Ethiopia.

41. Aleli AT. (2023). Chemical Compositions of Dairy Feed Resources at Haramaya University. J Fisheries Livest Prod. 11(5):420.

42. Aranguiz AA, Creemers J. (2019). Quick scan of Ethiopia's forage sub-sector. Working paper, Wageningen, Wageningen UR-Livestock Research.

43. Asrat A, Ayele A, Milkias K. (2015). Dairy Cattle Production Systems in Humbo Woreda, Wolaita Zone, Southern Ethiopia. Journal of Bio and Agri. 5(13).

44. Anteneh BT. (2006). Studies on cattle milk and meat production in Fogera woreda: Production systems, constraints and opportunities for development (Doctoral dissertation, Debub University, Ethiopia).

45. Mekonnen A. (2017). Assessment and Monitoring of Traditional Milking and Milk Product Handling, Processing and Marketing in Dessie Zuriea Woreda and Dessie Town, South Wollo Zone, Amhara, Ethiopia (Doctoral dissertation, Bahir Dar University).

46. Alemayehu N, Hoekstra D, Tegegne A. (2012). Smallholder dairy value chain development: The case of Ada'a woreda, Oromia Region, Ethiopia. ILRI (aka ILCA and ILRAD).

47. Zelalem Y, Emmanuelle G, Sebsibe A. (2011). A review of the Ethiopian dairy sector. FAO Sub Regional Office for Eastern Africa (FAO/SFE).

48. Gobena MM. (2016). Household dairy production system, marketing and constraints in Ethiopia. Journal of Marketing and Consumer Research. 29:46-52.

49. Felleke G, Woldearegay M, Haile G. (2010). Inventory of Dairy Policy–Ethiopia. Target Business Consultants Plc, Netherlands Development Organization (SNV), Addis Ababa, Ethiopia.

50. Getachew F, Asfaw T. (2003). Milk and dairy products, post-harvest losses and food safety in sub-Saharan Africa and the Near East. A review of the smallholder dairy sector-Ethiopia. FAO prevention of food losses program.

51. Redda T, (2001). Small-scale milk marketing and processing in Ethiopia. In Smallholder dairy production and market opportunity and constraints. Proceeding of a South–South workshop held at NDDB, Anand, India. pp. 352-367.

52. Asrat A, Feleke A, Ermias B. (2016). Characterization of Dairy Cattle Production Systems in and around Wolaita Sodo Town, Southern Ethiopia. Scholarly journal of Agricultural Science. 6(3):62-70.

53. Bekele A, Fekadu B, Mitiku E. (2015). Handling, processing and marketing of cow milk in urban and peri urban area of Dangila Town, Western Amhara Region, Ethiopia. Glob. J Food Sci Technol. 3(3):159-174.

54. Tsehay R. (2001). Small-scale milk marketing and processing in Ethiopia. In: Rangnekar D, Thorpe W, (eds). Smallholder dairy production and marketing—Opportunities and constraints. Proceedings of a South–South workshop held at NDDB, Anand, India.

55. Gebre WA, Alemayehu M, Demeke S, Bediye S, Tadesse A. (2000). Status of dairy development. Smallholder Dairy Development Project (SDDP) dairy research in Ethiopia. The role of village dairy co-operatives in dairy development. SDDP (Smallholder Dairy Development Project) Proceedings, MOA (Ministry of Agriculture), Addis Ababa, Ethiopia.

56. Liu P, Hendalianpour A, Hamzehlou M, Feylizadeh MR, Razmi J. (2021). Identify and rank the challenges of implementing sustainable supply chain blockchain technology using the Bayesian best-worst method. Technological and Economic Development of Economy. 27(3):656-680.

57. Assaminew S, Ashenafi M. (2015). Feed formulation and feeding impact on the performance of dairy cows in Central Highland of Ethiopia. Livestock Research for Rural Development. 27(4).

58. Gillah KA, Kifaro GC, Madsen J. (2012). Urban and peri urban dairy farming in East Africa: A review on production levels, constraints and opportunities. Livestock Research for Rural Development. 24(11):198.

59. Kaplinsky R. (2000). Globalisation and unequalisation: what can be learned from value chain analysis? Journal of development studies. 37(2):117-146.

60. Rich KM, Baker D, Negassa A, Ross RB. (2009). Concepts, applications, and extensions of value chain analysis to livestock systems in developing countries (No. 1005-2016-79380).

61. Gebremedhin B, Jemaneh S, Hoekstra D, Anandajayasekeram P. (2012). A guide to market-oriented extension services with special reference to Ethiopia. International Livestock Research Institute, Nairobi, Kenya.

62. Kiambi S. (2020). Value chain mapping to assess Governance challenges, food safety risks, and Escherichia coli genetic diversity along the Dairy food system in Nairobi Kenya (Doctoral dissertation, University of Nairobi, Kenya).

63. Vermeulen S, Woodhill AJ, Proctor F, Delnoye, R. (2008). Chain-wide learning for inclusive agrifood market development: A guide to multi-stakeholder processes for linking small-scale producers to modern markets. UK: International Institute for Environment and Development.

64. Zelalem Y, Yonas H, Takele W, Mitiku E. (2017). The Ethiopian Dairy Value Chain, Current Scenarios and Investment Opportunities. East African Journal of Sciences. 11(2).

65. Kiros A, Berhan T, Gebeyehu G, Tilaye D, Fekadu R. (2018). Assessment of Dairy Feed Resources and Feeding Frequencies in Selected Urban and Peri-Urban Areas of Central Highlands of Ethiopia. World Appl Sci J. 36(7):819-825.

66. Gemechu T, Amene T. (2017). Dairy cattle milk production, handling, processing, utilization and marketing system in Bench Maji Zone, Southwest Ethiopia. Int J Livest Prod. 8(9):158-167.

67. Jabbar MA. (2010). Policy barriers for dairy value chain development in Bangladesh with a focus on the North West region (No. 138-2016-2026).

68. Tegegne A, Gebremedhin B, Hoekstra D, Belay B, Mekasha Y. (2013). Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. IPMS Working Paper.

69. Gatwech T. (2012). Dairy production, processing and market system: a case study of Gambella, South West Ethiopia.Debra zeit, Ethiopia.

70. Getabalew M, Alemneh T, Akeberegn D. (2019). Dairy production in Ethiopia-Existing scenario and constraints. Biomed J Sci Tech Res. 16(5).

71. Davis K, Swanson B, Amudavi D, Mekonnen DA, Flohrs A, Riese J, et al. (2010). In-depth assessment of the public agricultural extension system of Ethiopia and recommendations for improvement. International Food Policy Research Institute (IFPRI) Discussion Paper. 1041:193-201.

72. Tangka FK, Emerson RD, Jabbar MA. (2002). Food security effects of intensified dairying: Evidence from the Ethiopian highlands (Vol. 44). ILRI (aka ILCA and ILRAD).

73. Yibrah T, Tsega B. (2017). Cross–sectional study on calf health and management problems on small scale dairy farms of Sidama and Gedio zones, Southern Ethiopia. J Veter Sci Med. 5(1):5.

74. Beredu Y, Biruk A. (2019). Reproductive Disorders in Dairy Cattle; Retrospective Study in Asella Town, Central Ethiopia. Dairy & Vet Sci J. 9(4):555767.

75. FAO. (2014). Impact of mastitis in small scale dairy production systems. Animal Production and Health Working Paper. No. 13. Rome.

76. Khan MZ, Khan A. (2006). Basic facts of mastitis in dairy animals: A review. Pakistan Vet J. 26(4):204-208.

77. Cervinkova D, Vlkova H, Borodacova I, Makovcova J, Babak V, Lorencova A, Vrtkova I, et al. (2013). Prevalence of mastitis pathogens in milk from clinically healthy cows. Vet Med. 58(11):567-575.

78. Haftu R, Taddele H, Gugsa G, Kalayou S. (2012). Prevalence, bacterial causes, and antimicrobial susceptibility profile of mastitis isolates from cows in large scale dairy farms of Northern Ethiopia. Trop. Anim. Health Prod. 44(7):1765-1771.

79. Radostits OM, Gay CC, Hinchcliff KW, Constable PD. (2007). Veterinary Medicine: A text book of the disease of cattle, horses, sheep, pigs and goats. 10th ed. London: Elsevier Ltd.

80. Harmon RJ. (1994). Symposium-Mastitis and Genetic Evaluation for Somatic Cell Count-Physiology of Mastitis and Factors Affecting Somatic Cell Counts. J Dairy Sci. 77(2):103-112.

81. Lakew M, Tolosa T, Tigre W. (2009). Prevalence and major bacterial causes of bovine mastitis in Asella, South Eastern Ethiopia. Trop Anim Health Prod. 41(7):1525-1530.

82. Abrahmsén M, Persson Y, Kanyima BM, Båge R. (2014). Prevalence of subclinical mastitis in dairy farms in urban and peri-urban areas of Kampala, Uganda. Trop Anim Health Prod. 46(1):99-105.

83. Groot MJ, Van't Hooft KE. (2016). The Hidden Effects of Dairy Farming on Public and Environmental Health in the Netherlands, India, Ethiopia, and Uganda, Considering the Use of Antibiotics and Other Agro-chemicals. Front Public Health. 4:12.

84. McDermott JJ, Staal SJ, Freeman HA, Herrero M, Van de Steeg JA. (2010). Sustaining intensification of smallholder livestock systems in the tropics. Livestock science. 130(1-3):95-109.

85. Land O'Lakes Annual reports, several issues (2010).

86. Nardos, E. (2010). Determinants, Challenges and Prospects of Dairy Production and Marketing (Doctoral dissertation, Mekelle University, Ethiopia).

87. Fraser D. (2008). Understanding Animal Welfare: The Science in Its Cultural Context Wiley-Blackwell, Oxford, UK.

88. World health organization of animal health, (2008).

89. USDA. (2007). Reference of Dairy Cattle Health and Management Practices in the United States, No. N480.1007. USDA-Anim. Plant Health Inspection Serv.-Vet. Serv., Centers Epidemiol. Anim. Health, Fort Collins, CO.

90. Cook NB, Nordlund KV. (2009). The influence of the environment on dairy cow behavior, claw health and herd health lameness dynamics. Vet J. 179(3):360-369.

91. Hammon DS, Evjen IM, Dhiman TR, Goff JP, Walters JL. (2006). Neutrophil function and energy status in Holstein cows with uterine health disorders. Vet Immunol Immunopathol. 113(1-2):21-29.

92. Leso L, Barbari M, Lopes MA, Damasceno FA, Galama P, Taraba JL, et al. (2020). Compost bedded-pack barns for dairy cows. J Dairy Sci. 103:1072-1099.

93. Webb DW. (2003). Artificial Insemination in Cattle. University of Florida, Gainesville. IFAS Extension, DS, 58. p. 2-5.

94. Temesgen T, Tibebu M, Usman L. (2017). Status and Constraints of Artificial Insemination in Dairy Cattle in Developing Countries: Review. Journal of Biology, Agriculture and Healthcare. 7(5):79-87.

95. Mohammed A. (2018). Artificial Insemination and its Economical Significance in Dairy Cattle. Int J Res Stud Microbiol Biotechnol. 4(1):30-43.

96. Valergakis GE, Arsenos G, Banos G. (2007). Comparison of artificial insemination and natural service cost-effectiveness in dairy cattle. Animal. 1(2):293-300.

97. CSA (Central Statistics Authority). (2016). Agricultural sample survey 2015/16. Vol. II. Report on livestock and livestock characteristics. Addis Ababa, Ethiopia.

98. Chebo C, Alemayehu K. (2012). Trends of cattle genetic improvement programs in Ethiopia: Challenges and opportunities. Livestock Research for Rural Development. 24(7):1-17.

99. Samre M, Alemayhu T, Weldegebriel S. (2015). Major Constraints of Artificial Insemination in and Around Alamata District, Tigray, Ethiopia. African Journal of Basic & Applied Sciences. 7(5):287-290.

100. Thomas CH. (2011). The Advantages and Disadvantages of Artificial insemination. Artificial insemination can produce a healthy foal.

101. Gebre Medhin D. (2005). All in one: A Practical Guide To Dairy Farming. Agri-Service Ethiopia Printing Unit, Addis Ababa, Ethiopia. pp. 15-21.

102. Desalegn G. (2008). Assessment of problems/ constraints associated with artificial insemination servicein Ethiopia. MSc Thesis, Addis Ababa University, Ethiopia.

103. MoARD. (2007). Livestock Master Plan Study Phase I Report Volume T–Sociological Aspects.

104. Hemme T, Otte J. (2010). Status and prospects for smallholder milk production: A global perspective. FAO, Roma (Italia).

105. Mayberry D, Ash A, Prestwidge D, Godde CM, Henderson B, Duncan A, et al. (2017). Yield gap analyses to estimate attainable bovine milk yields and evaluate options to increase production in Ethiopia and India. Agricultural Systems. 155:43-51.

106. Hooft KVT, Millar D, Geerlings E, Django S. (2008). Endogenous livestock development in Cameroon: Exploring the potential of local initiatives for livestock development. Agromisa Foundation, Wageningen, Netherlands.

107. Yilma Z. (2010). Quality Factors that Affect Ethiopian Milk Business: Experiences from selected dairy potential areas. Netherlands Development Organization, Addis Ababa, Ethiopia.

108. Sadler K, Kerven C, Calo M, Manske M, Catley A. (2009). Milk Matters.A literature review of pastoralist nutrition and programming responses. Feinstein International Center, Tufts University and Save the Children, USA.

109. Hoppe C, Rovenna Udam T, Lauritzen L, Mølgaard C, Juul A, Fleischer Michaelsen K. (2004). Animal protein intake, serum insulin-like growth factor I, and growth in healthy 2-5-y-old Danish children. Am J Clin Nutr. 80(2):447-452.

110. Ayza A, Yilma Z, Nurfeta A. (2013). Characterization of milk production systems in and around Boditti, South Ethiopia. Livestock and rural Development. 25(10).

111. Bekuma A, Galmessa U. (2018). Review on hygienic milk products practice and occurrence of mastitis in cow's milk. Agricultural Research & Technology: Open Access Journal. 18(2):1-11.

112. CSA. (2018). Agricultural sample survey 2017/18 report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin. pp. 587.

113. Eyassu S, Doluschitz R. (2014). Analysis of the dairy value chain: Challenges and opportunities for dairy development in Dire Dawa, Eastern Ethiopia. International Journal of Agricultural Policy and Research. 2(6):224-233.

114. Galmessa U, Dessalegn J, Tola A, Prasad S, Kebede LM. (2013). Dairy production potential and challenges in western Oromia milk value chain, Oromia, Ethiopia. Journal of Agriculture and Sustainability. 2(1).

115. Sendros D, Tesfaye K. (1998). Factors to be considered in the formulation of livestock breeding policy. In Proceedings of The Fifth National Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa. ESAP. pp. 13-27.

116. Tegegne A, Gebremedhin B, Hoekstra D, Belay B, Mekasha Y. (2013). Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. IPMS Working Paper.

117. Yigrem S, Beyene F, Tegegne A, Gebremedhin B. (2008). Dairy production, processing and marketing systems of Shashemene-Dilla area, South Ethiopia. IPMS Working Paper.

118. Yilma Z, Guernebleich E, Sebsibe A, Fombad R. (2011). A review of the Ethiopian dairy sector.: FAO sub-regional office for Eastern Africa (FAO/SFE). Addis Ababa, Ethiopia.

119. Yilma Z. (2012). Microbial properties of Ethiopian marketed milk and milk products and associated critical points of contamination: An epidemiological perspective. Epidemiology insights. 15:298-322.