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Assessing strategy to improve dairy production and milk quality under smallholder dairying: Evidence from Ethiopia

Eyob Mengesha, Habtamu Lemma Didanna* and Asrat Ayza

Wolaita Sodo University, POB 138, College of Agriculture, Ethiopia. *Author for correspondence. E-mail: lemmahab2015@gmail.com

ABSTRACT. Little information exists on effectiveness of the approach in the intervention programme delivered to smallholder dairy farmers. A comparative study was conducted to assess milk production and composition in two districts (Doyogena project area and Angacha as a control) and the associated dairy intervention. Data were collected through household survey and milk testing. The average daily milk yield of crossbred dairy cows was 6.91±1.14 litres, which was significantly ($p < 0.05$) different across districts. The overall mean fat, solids-not-fat, lactose, salts, protein, and total solids (TS) contents of crossbred cows' milk were 4.71±0.83, 8.85±0.36, 4.87±0.19, 0.72±0.03, 3.23±0.13 and 13.55±0.19 percent, respectively. The milk composition was significantly ($p < 0.05$) different across the study areas. Milk fat content is higher than the Ethiopian standard (ES); protein is also comparable. The major constraints for dairy production in the study areas were, in descending order, feed shortage in the dry season, land scarcity, lack of improved breeds, market access, and disease prevalence. To make livestock programs more impactful, strong extension and an integrated approach that encompasses improved feeds, breeding, marketing, and better health management are crucial to alleviate the diverse constraints of smallholder dairying while enhancing productivity and the associated food and nutrition security and livelihoods.

Keywords: milk yield; milk composition; dairy constraints; smallholders; dairy intervention.

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Introduction

According to the Sustainable Development Goals, the dairy sector agrees to give particular attention to the needs of family farmers, smallholders, and pastoralists. Dairy production is highly valued in many low- and middle-income countries (LMICs), and milk consumption is expected to rise significantly over the next several decades. In fact, global milk demand is anticipated to rise by 35% by 2030, driven primarily by increased demand in Asia, as well as Africa and Latin America (International Farm Comparison Network [IFCN], 2018). The growing demand for dairy products in LMICs is a potential to use dairying to improve the nutrition, health, incomes, and livelihoods of millions of people (Adesogan & Dahl, 2020).

In response to an increasing population, urbanization, rising income, and an emerging middle class, the demand for livestock products is growing rapidly in Ethiopia (Francesconi & Heerink, 2011; Shapiro et al., 2015), which offer opportunities for the smallholder farmers to use livestock as a pathway out of poverty and food insecurity. In order to meet the demand, farmers need to increase the productivity of their animals. Increasing productivity involves the use of technological inputs such as improved livestock genotypes, improved nutrition, and health care. Difficulties in accessing reliable and quality livestock feed resources, poor postharvest feed handling, and inefficient utilization practices are critical constraints to Ethiopia's livestock sector, alongside other key constraints such as animal health and breeding services (Shapiro et al., 2015; Effa et al., 2016; Balehegn et al., 2020).

If the constraints are well addressed, dairy development can contribute to food/nutrition security, increasing farm incomes and creating employment opportunities. Continuous improvement and advances will be crucial in management, nutrition, and genetics to improve milk yields over time to meet the challenge of producing sufficient dairy to supply the growing population in a sustainable way (Capper, 2012). However, there remains a lack of consensus among development partners that run smallholder dairy programs with support from donors, the private sector, and government dairy extension on which development or intervention strategy to use given the complex nature of smallholder farming.

With the increasing pressure on land and natural resources, small-scale farmers in the Kambatta Tembaro zone, located in southern Ethiopia, have been facing an acute fodder crisis, resulting in poor zootechnical performances, including low milk yield and quality. Providing a balanced feeding to livestock all year long remains a critical challenge for most farmers. To overcome this major constraint, Inter Aide France (2015) has been providing support with improved forages and training to smallholder dairy farmers since 2012 in the Doyogena district of the Zone. However, the approach of the intervention efforts has not been evaluated in order to find lessons and sustainable solutions. If addressed, it has the potential to fill gaps in the evidence base and better inform policies and future programmes on smallholder dairying. Therefore, a study was conducted to assess milk production and chemical composition as well as the accompanying intervention approach in Doyogena. Households were also sampled from Angacha district for comparison purpose. The current study is the first piece of work to assess the livestock intervention in the area.

Material and methods

Study area

The study was conducted in Doyogena and Angacha districts, Kembata Tembaro zone. Doyogena lies between 7º 20´ N latitude and 37º 50´ E longitude. It has an altitude that ranges from 1900 to 2300 m above sea level. The mean annual rainfall and temperature of the district ranges from 1,000 to 1,400 mm and 12.6°C to 20°C respectively (Abonesh, Abebe, & Gebermedihin, 2021).). There are 12392 crossbred dairy cows and 15372 indigenous cows. Angacha district lies between latitudes 7º 30’ N and longitudes 37º 83’ E. Topographically, it lies in an elevation range of 1700–2500 m above sea level. The mean annual temperature is 19.40˚C and the main annual rainfall is 1250 mm (Weldeamanuel & Cheng, 2024). There are 10119 crossbred dairy cows and 18572 local breed cows.

Inter-Aide France is an international NGO (non-governmental organization) specializing in the design and implementation of rural development projects. It has been operating in Ethiopia for more than three decades (http://interaide.org/). Since 2012, it has been implementing a dairy-related project in the Doyogena district of Kembata Tembaro Zone, southern Ethiopia.

Sampling procedures

Purposive sampling was used to select the study district and kebeles (smallest administrative units) based on their dairy production potential and NGOs' project intervention. Four kebeles from the two districts (Lemi suticho and Gomora from Doyogena, and Mesena and Gedelo from Angacha) were selected. The non-project site, Angacha district, was taken for comparison purposes. The total number of households with lactating cows was 240 in both districts.

The sample size was determined by using Yamane formula (1967): i.e. n = N/1+N (e) 2

where:

n = designates the sample size;

N = Total households owning milking cows and practicing dairy products marketing;

e = Level of precision or margin of error 7.4 % (0.074);

1 = designates the probability of the event occurring.

According to the formula, 150 households that own lactating dairy cows were selected randomly and interviewed individually using a semi-structured questionnaire.

Data collection

The study comprised a household survey using a semi-structured questionnaire and laboratory milk testing. This survey was conducted in Doyogena district (75 households), where an intervention programme (improved forages, mainly desho grass and elephant grass, and related training) was delivered to smallholder dairy farmers. Seventy-five (75) households were also sampled for the comparative study in Angacha district. A total of forty-five (45) (23 from Doyogena and 22 from Angacha) raw milk samples were collected from study areas among those surveyed dairy households. The milk samples were placed into different labelled volumetric flasks of about 40 mL capacity used for the analysis of chemical composition by using a Lactoscan. The milk samples were kept in an ice box and delivered for analysis following standard methods as described by O’Connor (1995).

Statistical analysis

The data obtained from the survey was checked and entered into the Microsoft Office Excel sheet. All the data were analyzed using the Statistical Package for Social Sciences (SPSS, 2014) version 23. Descriptive statistics (Chi-square tests, means, standard deviation, frequency, and percent) and General Linear Model (GLM) were employed to analyze the effect of independent variables on dependent variables.

The statistical model was used:

$Y_{ij} = \mu + Mi + \varepsilon_i$.

where:

Y_{ij} = Dependent variables (milk yield and chemical composition of raw milk);

μ = overall mean;

M_i = milk sources (Doyogena and Angacha districts);

ε_i = error term.

Indices were calculated according to the formula:

Index = [(3 × number of households ranking as first + 2 × number of households ranking as second + 1 × number of households ranking as third)] divided by sum of all mentioned by respondents

Results and discussion

Socio-economic characteristics of households

Most of the household heads surveyed (58.7%) were in the range of 45-54 years of age and were mostly male (87.3 %). The majority of them (81.3%) were illiterate. The mean (±SD) family size per household was 7.67±1.01. The overall landholding and cattle herd sizes of the study areas were 0.94±0.11 ha and 6.24±1.37, respectively (Table 1).

Table 1. Household characteristics.

Variable	Doyogena N = 75		Angacha N = 75		Overall N = 150	
	Mean±SD		Mean±SD		Mean±SD	
Family size	7.81±0.83		7.53±1.15		7.67±1.01	
Land holding	0.94±0.10		0.93±0.11		0.94±.0.11	
Cattle herd size	6.73±1.47		5.74±1.07		6.24±1.37	
	N	%	N	%	N	%
Education level Illiterate	59	78.7	63	84	122	81.3
Primary	8	10.6	6	8	14	9.3
Secondary and preparatory	8	10.7	6	8	14	9.3
Gender						
Male	70	93.3	61	81.3	131	87.3
Female	5	6.7	14	18.7	19	12.7
Age						
24-34	7	9.3	2	2.7	9	6
35-44	17	22.7	23	30.7	40	26.7
45-54	45	60	43	57.3	88	58.7
> = 55	6	8	7	9.3	13	8.6
Dairy experience						
< 5 years	6	8	10	13.3	16	10.7
6-10 years	11	14.7	17	22.7	28	18.6
> = 10 years	58	77.3	48	64	106	70.7
Occupation of household						
Trader	11	14.7	2	2.7	13	8.7
Farmers	64	85.3	73	97.3	137	91.3

N = number of respondents; SD = standard deviation of mean.

Dairy breeding methods

The breeding methods employed by dairy households were natural service (42%), artificial insemination (AI) (24.7%), and both AI and natural service (33.3%) (Table 2).

The AI service was provided only by the government/ministry of agriculture, which lacked institutional capacity and career incentives. This calls for private sector engagement to contribute to breeding efficiency.

Table 2. Breeding practices.

Variable	Doyogena N = 75		Angacha N = 75		Overall N = 150		P-value
	N	%	N	%	N	%	
Breeding methods							
Natural breeding	23	30.7	40	53.3	63	42	
Artificial breeding	22	29.3	15	20	37	24.7	0.014
Both	30	40	20	26.7	50	33.3	
Sources of crossbred cows							
Purchased	53	70.7	60	80	113	75.3	0.000
Through A. I	22	29.3	15	20	37	24.7	

N = number of respondents; P-value significance level.

Feeding system

Stall feeding with limited grazing was the common feeding system practiced among dairy households. Natural pasture, crop residues (straws of wheat, barley, faba bean, teff, and maize stalk), forage grass (desho grass and elephant grass), hay, and crop aftermath were predominant in the study areas (Table 3).

The availability of feed resources in the study area depends on the season (Table 3). The average dry (crop residues like straw, stover, and hay) and green (fresh or succulent grasses and legumes) fodders fed per cow per day appeared to be 7.03±1.31 kg and 10.01±0.84 kg, respectively (Table 4). The majority (65.3%) of the respondents offered concentrate in addition to forages and crop residues. The main reason for supplementing mostly milking cows was to maximize milk production. The average amount of concentrate (wheat and corn bran, and middling; cotton seed cake) supplemented to the milking cow per day was 1.3±0.42 kg.

The respondents reported that they were well aware of the high benefits of using concentrate supplements in increasing milk production; however, lack of capital, low availability, and high cost were reported to be the main limitations to their adequate utilization.

The experience of cultivating of improved forages was significantly different ($p < 0.05$) among the dairy households in Doyogena and Angacha districts (Table 4). Farmers preferred the improved grass due to its easy management as a feed source and its use on soil and water conservation structures.

The majority of households (64.7%) used river water for dairy production. The watering frequency was once a day. The mean values of daily water consumption in the study area were 9.33±0.94 and 16.06±2.05 L per day per cow for local and crossbred dairy cows, respectively. The mean distances of water points from homes were 1.45±0.37 km and 1.80±0.33 km, respectively, in Doyogena and Angacha districts, with an overall mean of 1.63±0.39 km (Table 5). As estimated by Jenet, Yimegnuhal, Tegegne, Fernandez-Rivera, and Kreuzer (2004), crossbred cows consume 52.6 kg of water daily, including the water in feed. Therefore, no sufficient water was provided for the dairy cows.

Table 3. Feeding system.

Variable	Doyogena N = 75		Angacha N = 75		Overall N = 150		P-value
	N	%	N	%	N	%	
Feeding systems							
Free grazing	5	6.7	25	33.3	30	20	
Stall feeding	23	30.6	15	20	38	25.3	0.001
Stall feeding with limited grazing	47	62.7	35	46.7	82	54.7	

Seasonality ranking of feed resources

	Variables	Doyogena N = 75		Angacha N = 75		Overall N = 150	
	Major feed resources	Index	Rank	Index	Rank	Index	Rank
Dry season	Crop residues	0.29	1st	0.36	1st	0.32	1st
	Crop aftermath	0.28	2nd	0.28	2nd	0.28	2nd
	Hay	0.17	3rd	0.16	3rd	0.17	3rd
	Fodder trees/forage	0.13	4th	0.12	4th	0.13	4th
	Natural pasture	0.07	5th	0.04	5th	0.06	5th
	AIBP	0.05	6th	0.03	6th	0.04	6th
Wet season	Natural pasture	0.32	1st	0.31	1st	0.32	1st
	Fodder trees/forage	0.26	2nd	0.24	2nd	0.25	2nd
	Crop residues	0.18	3rd	0.24	3rd	0.21	3rd
	Dry grass hay	0.13	4th	0.13	4th	0.13	4th
	Crop aftermath	0.07	5th	0.06	5th	0.06	5th
	AIBP	0.04	6th	0.02	6th	0.03	6th

Key: AIBP: Agro-industrial by products (wheat and corn bran and middling and cotton seed cake).

Table 4. Feed type offered and supplementation for dairy cattle in study area.

Variables	Doyogena N = 75		Angacha N = 75		Overall N = 150		P-value
	Mean±SD		Mean±SD		Mean±SD		
Feed type offered (kg)							
Dry fodder	8.11±0.66		5.95±0.82		7.03±1.31		0.000
Green fodder	10.27±0.95		9.75±0.63		10.01±0.84		0.000
Concentrate	1.41±0.48		1.17±0.31		1.3±0.42		0.000
	N	%	N	%	N	%	
Groups of animals more supplemented							
Lactating cows	60	80	70	93.3	130	86.7	0.016
Both pregnant and lactating cows	15	20	5	6.7	20	13.3	
Supplementary feeding							
Yes	60	80	38	50.7	98	65.3	0.000
No	15	20	37	49.3	52	34.7	
Frequency of feeding supplements							
Never	15	20	37	49.3	52	34.7	
Once a day	60	80	18	24	79	52.7	0.010
Occasionally	-	-	20	26.7	20	13.3	
Experience of growing improved forages							
Yes	65	86.7	32	42.7	97	64.7	0.000
No	10	13.3	43	57.3	53	35.3	

Table 5. Daily water source and consumption.

Variable	Overall N = 150	
	%/Mean	
Daily water consumption per animal in L		
Local	9.33±0.94	
Cross	16.06±2.05	
Distance of water source from home (km)	1.63±0.39	
Sources of water	N	%
River	97	64.7
Pond	24	16
Wells	29	19.3

N: number of respondents.

Milk production

The average daily milk yield of crossbred dairy cows in the study areas was 6.91±1.14 L. The average daily milk yield and lactation length of crossbred dairy cows in Doyogena and Angacha differed significantly ($p < 0.05$). (Table 6). The current finding is higher than Bekuma, Fita, and Galmessa (2022) (5.83±0.28 L); Beriso, Tamir, and Feyera (2015) (4.69L); and Demeke (2020) (4.62±0.35 L) daily milk yield per cow in Ethiopia. The present finding is also comparable with that reported by Girma, Jerjero, and Mekuria (2017) (6.49 L). The relatively higher amount of milk per day produced in the project site (Doyogena district) was probably due to the availability of diverse feed types and more dairy experience.

The overall average lactation length of crossbred dairy cows in the study areas was 8.42±0.68 months. The overall average lactation length of local and cross-bred dairy cows in the current study was in line with Bekuma et al. (2022) (8.87±0.18 months) elsewhere in Ethiopia. The current finding is in line with that of Gebeyew, Amakelew, Eshetu, and Animut (2016), who reported an average lactation length of 8.37 months. But it is lower than that of Demeke (2020), who reported an average lactation length (10.8±1.02 months) and Beriso et al. (2015) (10.61±0.4 months) in Ethiopia.

In the study area, the effect of household characteristics of the respondents on milk yield was significantly different ($p < 0.05$) with respect to dairy experience, family labor, land size, and age of household heads (Table 7), which have a positive role on milk production. The result obtained in the present study was in agreement with that of earlier studies (Duguma, Tegegne, & Hegde, 2012), which reported that the effects of socio-demographic characteristics of respondents on milk yield showed significant differences in Jimma. The relatively higher milk yield from male-headed households might be due to the higher number in studied areas and associated differences in resource access and gender inequality in the community, given that the that the majority are illiterate.

Table 6. Milk production.

	Variables	Doyogena N = 75	Angacha N = 75	Overall N = 150	P-value
		Mean±SD	Mean±SD	Mean±SD	
Local dairy cows	DMY (L)	1.43±0.49	1.17±0.31	1.30±0.43	0.000
	Lactation milk yield (L)	286±99.66	233.10±61.65	259.55±86.74	0.000
	LL (months)	6.653±0.348	6.63±0.36	6.64±0.35	0.731
Cross dairy cows	DMY (L)	7.90±0.48	5.913±0.622	6.91±1.14	0.000
	Lactation Milk yield (L)	2062.40±160.01	1434.80±203.53	1748.60±363.89	0.000
	LL (Months)	8.79±0.36	8.05±0.73	8.42±0.68	0.000
Milking frequency per day (%)					
Twice		75	75	100	---

DMY: daily milk yield; LL: lactation length.

Table 7. Effects of household characteristics on milk production in study areas.

Variable	N	Daily milk yield*
		Mean and SE
		8.21±1.34
Gender		
M	131	8.34±1.33
F	19	7.26±0.93
p-value		0.001
Age		
24-34	9	8.89±1.31
35-44	40	8.60±0.98
45-54	88	8.04±1.41
> = 55	13	7.69±1.52
p-value		0.027
Land size		
< 1 ha	131	8.11±1.34
> = 1 ha	19	8.92±1.14
p-value		0.013
Family size		
5-8	74	7.88±1.08
> = 8	76	8.53±1.49
p-value		0.003
Education level		
illiterate	122	8.07±1.31
primary	14	8.82±1.64
Secondary	14	8.78±1.03
p-value		0.033
Supplementary feeding		
Wheat bran	75	8.65±1.06
Cotton seed cake	23	9.28±1.04
p-value		0.013
Dairy experience		
< = 5 years	16	7.37±1.56
6-10 years	28	7.96±1.42
> = 10 years	106	8.40±1.23
p-value		0.009

*Overall local and crossbred cows.

Chemical compositions of raw milk

The overall mean fat, solids-not-fat, lactose, salts, protein, and total solids (TS) contents of local cows' milk produced in the study area were 6.80±1.39, 8.75±0.50, 4.82±0.27, 0.72±0.04, 3.16±0.18 and 15.44±1.51 percent, respectively (Table 8). Whereas the overall mean fat, solids-not-fat, lactose, salts, protein, and total solids (TS) contents of milk from crossbred dairy cows were 4.71±0.83, 8.85±0.36, 4.87±0.19, 0.72±0.03, 3.23±0.13 and 13.55±0.19 percent, respectively. Milk samples from crossbred dairy cows in the Doyogena district were significantly higher ($p < 0.05$) in percent fat (5.01±0.73), SNF (9.02±0.34), lactose (4.97±0.18), salts (0.74±0.02), protein (3.29±0.02) and TS (14.02±0.63) contents than those from Angacha. The variation in chemical composition of raw milk in the study areas may be attributed to differences, among others, feeds and feeding practices, stage of lactation, and parity. Milk fat and protein contents varied significantly ($p < 0.05$) across dairy cow genotypes. This variation might be due to feed and breed differences besides stage of lactation, and age of animals (Yoseph, Didanna, & Ayza, 2022).

Table 8. Chemical composition of raw milk produced in study area.

Variable	Districts				Overall		P-values	
	Doyogena		Angacha					
	Local	cross	Local	cross	local	cross	Districts	Breeds
Fat%	7.13±1.15	5.01±0.73	6.42±1.13	4.37±0.82	6.80±1.39	4.71±0.83	0.034	0.000
SNF%	9.00±0.53	9.02±0.34	8.46±0.25	8.65±0.28	8.75±0.50	8.85±0.36	0.029	0.460
Lactose%	4.96±0.29	4.97±0.18	4.66±0.13	4.76±0.15	4.82±0.27	4.87±0.19	0.003	0.499
Salts%	0.74±0.04	0.74±0.02	0.70±0.02	0.70±0.02	0.72±0.04	0.72±0.03	0.03	0.975
Protein%	3.25±0.19	3.29±0.12	3.06±0.10	3.15±0.10	3.16±0.18	3.23±0.13	0.035	0.021
TS%	16.13±1.69	14.02±0.63	14.64±0.79	13.02±0.91	15.44±1.51	13.55±0.19	0.04	0.00

Means $^{a-b}$with different superscripts for the same variable across the same row are significantly different ($p < 0.05$).

The overall mean fat percentages of local and crossbred dairy cows in the study area were 6.80±1.39 and 4.71±0.83, respectively. The overall mean value of milk fat is higher than that of the Ethiopian Standard (3.50%) (Ethiopian Standard [ES], 2023). Moreover, the milk fat from local breeds of cows is higher than milk samples from crossbred dairy cows due to the difference in dairy genotypes.

The overall mean fat percent of milk from indigenous cows obtained in this study is comparable with that reported by Debela, Eshetu, and Regassa (2015) (6.01%). The overall mean fat percent of milk from crossbred cows obtained in this study is slightly higher than that reported by Desyibelew and Wondifraw (2019) (4.12±0.26%); Shibru and Mekasha (2016) (4.10±0.77%) in other regions of Ethiopia. The overall mean protein contents of local and cross-bred cows were 3.16±0.18 and 3.23±0.13%, respectively (Table 8). The current finding was comparable with that of the Ethiopian Standard (3.2%) (ES, 2023) and Dehinenet, Mekonnen, Ashenafi, and Emmanuelle (2013) (3.12±0.32), but higher than Desyibelew and Wondifraw (2019) (2.83±0.06%). The current result is lower than the previous study by Debela et al. (2015) (3.94%) and Fikrineh, Estefanos, and Tatek (2012) (3.46 %) elsewhere in Ethiopia. The difference might be due to the variability of feeds, dairy genotypes, and stages of lactation.

The solid non-fat percentage composition of milk sampled from the study area was 8.75±0.50 and 8.85±0.36 for local and crossbred dairy cows, respectively. This is higher than that set by ES (2009). The current result was in agreement with Dehinenet et al. (2013) (8.88±0.83%) of solid-fat percentage, Tesfay, Kebede, and Seifu (2015) (8.75%) and Fikrineh, Estefanos, and Tatek (2012) (9.05%). The overall values of this study for SNF% were higher than those of Desyibelew and Wondifraw (2019) (7.77±0.14%), but much lower than those reported by Debela et al. (2015) (9.46%) elsewhere in Ethiopia.

The overall lactose percent of milk sampled from the study area was 4.82±0.27% and 4.87±0.19 for local and cross-bred cows, respectively (Table 8). The current result is higher than Desyibelew and Wondifraw (2019) (4.28±0.08%); Sebho and Meskel (2018) (4.24%); and Gemechu, Beyene, and Eshetu (2015) (4.43±0.06). But this current result is less than the previous study reports of Aysheshim, Beyene, and Eshetu (2015) (5.07%) and Debela et al. (2015) (5.52%±1.71).

The overall salt contents of milk from local and crossbred dairy cows in the study area were 0.72±0.04 and 0.72±0.03%, respectively. The current finding is higher than that of Desyibelew and Wondifraw (2019) (0.63±0.01%); Fekade and Mekasha (2016) (0.6%); and lower than the finding of Debela et al. (2015) (0.80%).

The overall total solids percent of milk in the study was (15.44±1.51) and 13.55±0.19 for local and cross-bred cows, respectively (Table 8). These values are higher than the Ethiopian standard (12.8%) (ES, 2023). On the other hand, the finding is comparable with Hawaz et al. (2015) (13.1%), but higher than another report by Desyibelew and Wondifraw (2019) (11.89±0.40%).

Main constraints of dairy production

The major constraints for dairy production in the study areas were, in descending order, feed shortage in the dry season, land scarcity, lack of improved breeds, market access, and disease prevalence that affected improved milk production performance for smallholders (Table 9). This is in line with previous studies in different parts of the country (Duguma et al., 2012; Gurmessa, Tolemariam, Tolera, Beyene, & Demeke, 2016).

The dairy constraints faced by smallholder dairy farmers call for a holistic intervention approach to ensure sustainable solutions rather than only a problem-targeted intervention such as forage development. Controlled crossbreeding and related input supply, alternative formal marketing options (Didanna, Wossen, Worako, & Shano, 2018); and proper veterinary service are also crucial for improving productivity of smallholder dairy production.

Table 9. Main constraints for dairy production.

Variable	Doyogena N = 75		Angacha N = 75	
	Index	rank	Index	Rank
Main constraints for dairy production				
Feed shortage	0.31	1st	0.32	1st
Land scarcity	0.29	2nd	0.27	2nd
lack of improved breeds	0.19	3rd	0.18	3rd
Market access	0.14	4th	0.15	4th
Diseases	0.07	5th	0.08	5th

Conclusion

This paper assessed production and chemical composition of milk in the project and non-project districts, associated challenges and suggested appropriate and sustainable strategy/approach for dairy intervention. The district with NGO-intervention program has a relatively greater number of crossbred dairy stock, dairy experience, diverse feed resources, intensified/stall feeding (improved forage and feed supplementation), and more milk production and compositional quality (fat and protein). However, there are still multiple problems: feed shortage, lack of improved breeding, a formal market, and health care that affect milk quality and productivity per cow.

A holistic technique needs to be devised to overcome the identified problems and enhance the productivity of the dairy sector. There is a need for introducing forage legumes in a mixed stand and/or intercropping to replace part of the high cost of concentrate supplementation. Scaling up the already well-adapted forage grass species, urea treatment, and water development are also additional strategies. Market access for fresh milk through the organization of cooperatives or milk groups and/or the introduction of small-scale processing techniques is also important. The education level of the household heads shows a significant and positive relationship with milk yield. Educating dairy farmers is important to better adopt technical knowledge, on top of their experiences. In general, an integrated or pluralistic approach that encompasses improved feeding, breeding, marketing, and better health management is crucial for having more impactful dairy programs and alleviating the constraints of smallholder dairying while enhancing productivity and the associated food and nutrition security and livelihoods.

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