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Socio-economic aspects related to feeding resources and practices in selected intensive dairy farms in Central Ethiopia

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Dairy cattle productivity is affected by many factors such as genetics, infectious diseases, husbandry and diet. Fodder resources, fodder availability and feeding strategies were assessed by means of questionnaires and interviews in seventeen dairy farms in Addis Ababa, Sendafa and Debre Zeit. Nutrient content was analyzed from hay sample. The farms were categorized as small, medium or large. Nutrient content, as well as milk production for the given rations were estimated per farm. Results showed that most farms were landless and grass availability was seen in only 1/3 of the farms. Purchased hay was of poor quality and needed to be bulked stored for the year. Storage capacity and quality varied with farm size. Supplemental feed varied by farm size and many of them were available only seasonally and were costly. With the exception of large farms, quality of fodder was poor in 70% of the farms, hence likely impacting animal productivity and health. Overall, constraints related to feeding and animal performance were: low fodder quality containing too little protein and energy, poor fodder storage condition, seasonal and costly fodder availability, poor feeding strategy, and lack of knowledge of small and medium farm owners regarding dairy husbandry and feeding management.

Key words: Ethiopia, fodder, dairy cattle, productivity, feeding management.

INTRODUCTION

The livestock subsector contributes 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP to Ethiopia's national economy and to the livelihoods of many Ethiopians as about 80% of the population depends on it (CSA, 2015; CIA, 2018). Ethiopia with 54 million heads, has the biggest cattle herd in Africa (CSA, 2015). However, nearly 99% are local zebu breeds (*Bos indicus*) that produce little amounts of milk (0.5 to 2 L/day) and have multi-purpose functions in small holder farmer's lives. High productive improved breeds of *B. taurus* type-predominantly Holstein Friesians and their crosses with local breeds are mainly found in

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urban and peri-urban livestock systems and make up 1% of the total cattle population (Leta and Mesele, 2014).

Ethiopia with 106 million people is the second most populous country in Africa with a growth rate of over 2.48%. With this rapidly growing human population and swift expansion of urban areas across the country, the demand for liquid milk and milk products is also increasing fast. In addition to its vital dietary aspects, milk production can be a major contribution to household economies and the economy at large. The Ethiopian Government plan, as stated in its Growth and Transformation Plan II, is to drastically increase over the next 5 years, the milk production and milk safety in the country (GTP II, 2016). The dairy industry is currently facing many challenges such as lack of veterinary services, fodder shortages, infectious diseases and poor breeding programs among other factors. Hence, the full potential of dairy animals is often not met. In average, improved dairy cows in the intensive dairy farming sector were shown to produce between 673 and 3700 liter milk per lactation as compared to over 5000 liter per lactation in Zimbabwe (Ayalew et al., 2015; Tadesse et al., 2010; Tadesse and Dessie, 2003; Ngongoni et al., 2006). Many factors have been shown to affect milk productivity, including infectious diseases such as Bovine tuberculosis (Hernandez and Baca, 1998; Boland et al., 2010). However, quantitatively and qualitatively adequate feeding of dairy animals remains a key parameter to maximize milk production and maintain animals in good health. Research on feeding strategies, fodder availabilities and constraints are scarce in Ethiopia.

The objectives of this study were 1) to describe qualitatively and quantitatively, the fodder used in selected dairy farms, 2) to identify constraints related to optimal fodder supply and 3) to assess whether fodder and feeding management has a potential impact on poor milk productivity and animal health.

MATERIALS AND METHODS

Study farms

This research is part of a larger study investigating the burden of bovine tuberculosis (BTB) in intensive dairy farms, and its potential impact on animal productivity. Seventeen farms that took part in this larger study were chosen for this fodder study based primarily on willingness of farm owners to participate, logistics and on having a geographical and farm size representation.

Investigated farms were all intensive urban dairy farms in the capital city Addis Ababa, Debre- Zeit and Sendafa (within a 50 km radius from the capital). The 17 farms were classified as small (1-10 cattle), medium (11-50 cattle) and large (>50 cattle). The study was carried out between July 2016 and December 2016. Cows were all hand-milked twice a day.

Study tools

Questionnaires and interviews

Farms were visited monthly and animal productivity parameters (fertility, milk, morbidity and mortality) were recorded as part of the BTB study. In addition, a semi-structured questionnaire was prepared in English, translated into Amharic, pre-tested and administered by the same person throughout the study. The questionnaire captured information on general husbandry, crops grown on farms and/or purchased, description of rations (qualitative and quantitative) given, feeding strategies and assessment of fodder and water quality as well as fodder sources and costs. Informal discussions/interviews were held with farmers, middlemen and fodder suppliers.

Personal observation

The research team observed how fodder was stored, prepared and fed to animals. Fodder was qualitatively assessed by touching, smelling and visualizing (e.g. presence of mold, freshness, length of fibers, size of grains) and categorized into very good-acceptable and very bad fodder quality. Storage facilities were inspected and listed depending on size, ventilation, sheltering from weather and rodents into 3 categories: very good, acceptable and very bad. Water sources, quality and quantity given were also observed directly. Fodder sources and markets in and around Addis Ababa were visited. Fodder transportation to farms was observed.

Field trial

A small scale demonstration was performed in one of the large farms that feed on elephant grass (*Pennisetum purpureum*). The usual practice is that farmers cut the grass when it reaches 3 m. During 5 days, 2 cows were given young elephant grass cut when they reached 1 m. Daily milk yields were recorded in these 2 cows earlier, during and after the trial.

Fodder analysis

Fodder from one selected farm was sent to UFAG Laboratories AG in Switzerland for analysis of their nutritional value.

Data management and analysis

Data was entered in Microsoft Excel spreadsheet and analyzed with STATA/IC 13.1 software. Descriptive analysis was conducted and results shown in tables and graphs. Chi square test was used to investigate statistical significance between groups such as farm size or geographical location. The nutrient value required by the animal and the amount of nutrients that the cow gets from the available rations was calculated using the methods described by Moran (2005). In short: the maximum dry matter intake was estimated using the following formula: Maximum dry matter intake (kg/day) = (120/NDF%)/(100 × LWT), where NDF is neutral detergent fibre and LWT is live weight. The daily energy, protein and fiber requirements of the dairy cows for maintenance, activity, pregnancy and milk production were calculated using the values given in the tables presented by Moran (2005). The energy, protein and fiber contents of the given diets, and hence the milk production potential, were estimated using forage and feed values from the literature.

Ethical clearance

This study received institutional (AHRI Ethics Review committee) and national ethical clearance (NRERC) with respective reference numbers P046/14 and 3.10/001/2015.

Table 1. Herd composition in the 17 intensive dairy farms (total cattle: 562)

Cattle category	Farm size	Mean % of total herd size	SD for the mean	Range	p-value
Adult females	Large	51.8	7.7	43.8-62.2	0.28
	Medium	52.8	12.5	31.6-69.2	
	Small	51.8	7.7	43.8-62.2	
	Overall	52.6	10.9	31.6-69.2	
Heifers	Large	34.3	10.5	21.6-47.4	0.45
	Medium	29.1	13.9	11.1-52.6	
	Small	31.9	6.4	25-37.5	
	Overall	30.8	11.8	11.1-52.6	
Calves	Large	12.8	3.1	8.8-16.2	0.37
	Medium	15.6	5.8	7.7-23.5	
	Small	15.3	16.8	0-33	
	Overall	14.9	7.6	0-33	
Adult bulls	Large	1	2.1	0-4.2	0.69
	Medium	2.5	4.3	0-11	
	Small	0	0	0	
	Overall	1.7	3.5	0-11	
Oxen	-	-	-	-	-

RESULTS

Dairy herd and land size

Table 1 shows herd composition in the study farm. Overall, adult dairy cows and heifers accounted for 83.4% of the herd size. The average landholding size was 5.7 ha per farm. However, there was a large disparity between the farms. Five out of 17 farms (29.4%) had neither grazing land for cows nor crop land, hence depended on purchasing all basic roughages. Cattle in these farms never left the indoor stables. The remaining 12 farms had land for their livestock but only 6 farms (35.3%) had actual grazing land for their animal while 1 farm was grazing his cattle off-farm, in neighboring public green spaces. The remaining 5 farms owning land, used an average of 0.3 ha for recreational purposes only. These areas were made of concrete or dirt and allowed animals to get fresh air and movements. Availability of grazing land was not related to farm size (p: 0.90) nor farm location (p: 0.45).

Grazing time, when available was variable, from a couple of hours daily to a couple of hours weekly. Grazing was also seasonal depending on the rainy seasons and thus grass availability. Grass was hardly available during the dry months (February-June).

On average, cattle density was 9 cattle per hectare area allocated to livestock (grazing and recreational areas). Considering only areas used for grazing and farms having grazing land, cattle density increased to 25 animals per hectare. Six farms (35.3%) had additionally other livestock.

Two farms (1 medium and 1 large) (11.8%) produced crops for human consumptions (maize, teff, wheat and vegetables) and fed the animals seasonally with crop residues. All 4 large farms produced cattle fodder; 2 grew alfalfa and 4 grew elephant grass. Feeding of alfalfa and elephant grass was intermittent, every 3 weeks and only for selected animals (the best cows).

Fodder and water rations

The 4 most prevalent fodders fed on were hay, wheat bran, cotton seed cakes and brewery by-products. Types of fodder however, differed by farm size (Table 2). Overall, large farms provided a larger variety of fodder types than medium and small farms (Figure 1) and provided animals regularly with fresh roughages such as fresh grass, alfalfa and elephant grass, grown seasonally on-farm. Two medium farms in Addis Ababa feed animals on green Enset leaves (*Ensete ventricosum*) collected from markets. Only 3 farms (17.6%) supplemented the animal diet with purchased commercial concentrates. Farms used home-made supplementary feeds that were either locally available (permanent or seasonal) and/or affordable. On-farm crop residues were found in 3 farms only whereas the remaining 14 farms had to purchase all supplements. Availability, source and cost of the different fodders are shown in Table 3.

Provision of water

Mean quantity of daily water given to animals varied by

Table 2. Type of fodder given by farm size. Percentages are shown in brackets.

Fodder	Small farm (N=3)	Medium farm (N=10)	Large farm (N=4)	p-value
Grass	1 (33.3)	5 (50)	4 (100)	0.140
Alfafa	0 (0)	0 (0)	2 (50)	0.025
Elephant grass	1 (33.3)	0 (0)	4 (100)	0.001
Enset	0 (0)	2 (20)	0 (0)	0.452
Wheat bran	3 (100)	10 (100)	4 (100)	-
Nough	1 (33.3)	6 (60)	4 (100)	0.168
Brewery by-products	1 (33.3)	8 (80)	1(25)	0.103
Pea straw	1 (33.3)	7 (70)	0 (0)	0.05
Wheat straw	0 (0)	4 (40)	1 (25)	0.401
Maize	0 (0)	0 (0)	2 (50)	0.025
Molasses	0 (0)	1 (10)	3(75)	0.02
Concentrates	1 (33.3)	2 (20)	0 (0)	0.496

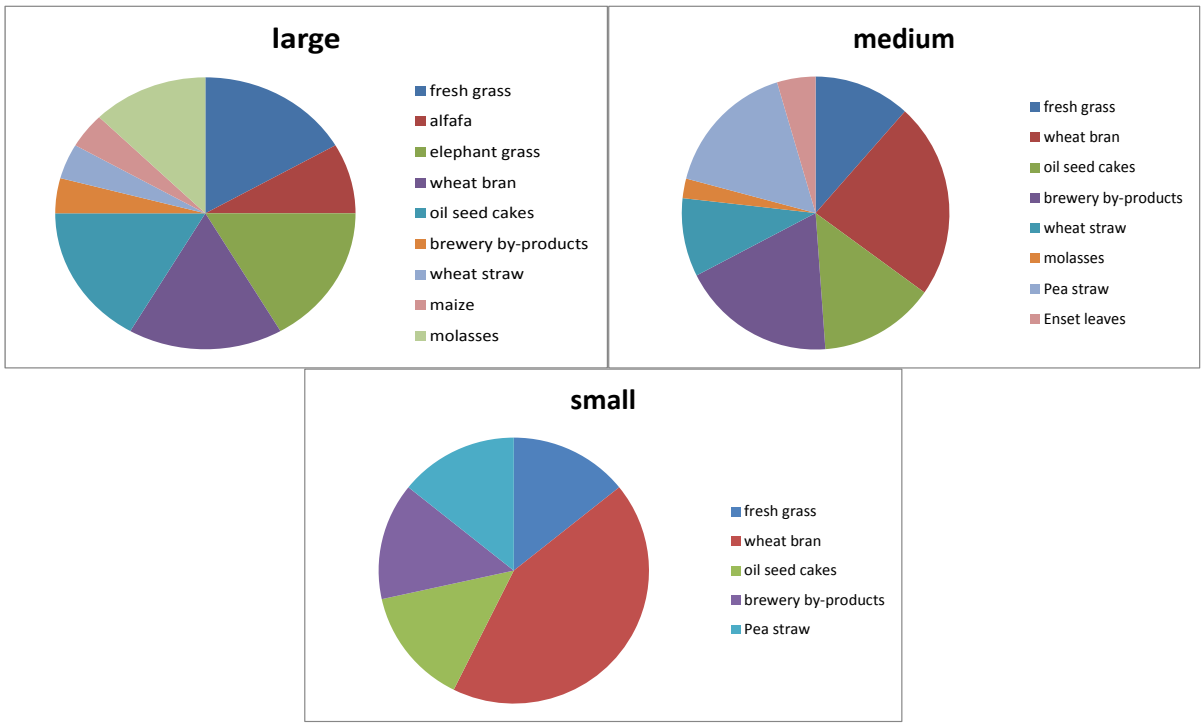

Figure 1. Fodder variety by farm size

farm and farm size with small farms providing the least water amount (Table 4). Large farms generally provided water *ad libitum,* whereas in small and medium farms, animals were watered with buckets twice a day. Additional water supplies came from watering troughs in the outside areas in 5 farms. Supplements such as crop residues, oil seed cake, maize, bran, brewery by-products were mixed with water before feeding.

Tap water provided the regular watering in 16 farms (94%), whereas 1 farm (5.9%) additionally purchased water, whereas another farm entirely relied on purchasing water. Two farms (11.8%) had underground water sources and 3 farms (17.6%) collected rain water. Water quality was ranked as very good in 2 farms (11.8%), both being large farms, good in 13 farms (76.5%) and bad in 2 farms (11.8%). The latter was in one large and one small farm.

Table 5 shows the results of nutrient content analysis of hay. Overall, nutrient values (CP, crude fat and glucose) and digestibility of organic matter were well below the reference range for quality hay, whereas crude fiber was well above the ideal range. These results were

Table 3. Availability, source and cost of fodder

Fodder	Type	No. (%)	Source	Location	Availability	Cost range (birr per quintal =100 kg)
Roughages	Fresh grass	8 (47)	On-farm/neighborhood		Seasonal	
	Hay	17 (100)	Purchased Produced (N=1)	Sendafa, Sululta	Yearly	300-400
	Enset leaves	2 (11.8)	Transport cost only	Local market	Yearly	100 per truck
Cultivated grass	Alfalfa	2 (11.8)	On-farm		Seasonal	
	Elephant grass	4 (23.5)	On-farm		Seasonal	
Crop residues	Wheat straw	6 (35.3)	Purchased On-farm	Mainly Sululta	Yearly Seasonal	80-90
	Pea straw	7 (41.2)	Purchased	Mainly Debre Berhan	Seasonal	120-300
	Vegetables (tomato, salad, cauliflower, cabbage)	2 (11.8)	On-farm		Seasonal	
Industrial by-products	Wheat bran	17 (100)	Purchased	Addis Ababa, Bale, Debre Zeit, unknown	Yearly	300-520
	Oil seed cake (cotton and noug)	11 (64.7)	Purchased	Addis Ababa, Adama, unknown	Yearly	400-700
	Brewery by-products	10 (58.8)	Purchased	Addis Ababa, Sebeta, Debre Birhan	Yearly	130-225
	Molasses	3 (17.6)	Purchased	Sugar factories		
Other	Maize residues	2 (11.8)	On-farm		seasonal	
	Purchased concentrates	3 (17.6)	Purchased	Debre Zeit; Special animal fodder shops	yearly	650- 800
	Minerals/Vitamins	10 (58.8)	Purchased	Special animal fodder shops	yearly	500-1000
	Salt	17 (100)	Purchased	Local shops	yearly	400-600

Table 4. Cattle watering by farm size

Farm Size	Mean liter/cow /day	SD	Range liter/day	Watering technique	Frequency
Small	23.3	11.5	10-30	Bucket	Twice/day
Medium	42.5	20.3	20-75	Bucket	Twice/day
Large	85	19.1	60-100	Individual cow bowl	*Ad libitum*

comparable to straw in Switzerland.

Nutrients level in the food ration and milk production potential

Cows were milked by hand twice a day. The average daily milk yield (DMY) reported was 11.24 L, which is comparable to values reported in other studies: in the central highlands (Bereda et al., 2017), Arsi zone (Solomon, 2010) and Amhara region (Belete, 2006).

Table 6 shows the nutrient value received on average by each cow on each farm of the study. Based on the estimated energy content of the rations, the milk production potential (MPP) was calculated. The maximum MPP was 14.5 liter per day and is in general below the average daily collected milk reported by the farmers. Moreover, many rations were not balanced, with a crude protein content below the recommended 14 to

Table 5. Laboratory analysis of hay collected from a selected study dairy farm (UFAG Laboratories AG, Sursee, Switzerland)

Nutrient	Result value	Ideal reference range
Dry Matter (DM)	905 g/kg	850-950 g/kg
Crude Ash (CA)	79 g/kg DM	80-120 g/kg DM
Crude Protein (CP)	45 g/kg DM	110-190 g/kg DM
Crude Fiber	365 g/kg DM	210-260 g/kg DM
Crude Fat	17 g/kg DM	20-35 g/kg DM
Digestion coefficient of organic matter	51.3%	75-79%
Glucose	38.8 g/kg DM	70-150 g/kg DM

Table 6. Nutrient values of fodder ration in the 17 farms by farm size and Milk Production Potential (MPP)

Farm size	Dry matter (Kg)	Crude Protein (Kg)	Crude Fiber (Kg)	Metabolic Energy (MJ)	Crude Protein (%DM)	Crude Fiber (%DM)	Calculated MPP*	Orally Reported milk production
Large	16.444	3.10292	4.17176	129.054	18.8696	25.3695	13.6	15
Large	15.666	1.70849	4.15284	122.7325	10.9057	26.5086	14.5	18
Large	11.52	1.28857	2.69469	94.7815	11.1855	23.3914	9.5	14
Large	15.165	2.33533	4.03548	114.9775	15.3994	26.6105	13.1	15
Medium	12.799	1.6742	3.23064	115.0785	13.0807	25.2413	8.5	13
Medium	10.627	1.86171	2.58492	86.2975	17.5186	24.3241	8.1	10
Medium	9.587	1.11555	2.34065	104.9735	11.6361	24.4148	8.4	12
Medium	8.3	1.19845	2.10165	72.592	14.4392	25.3211	5.7	10
Medium	9.85	1.35275	2.50662	87.425	13.7335	25.4479	8.4	9
Medium	12.01	1.83371	3.14929	90.398	15.2682	26.2222	8.8	15
Medium	10.515	1.25785	2.95481	78.1675	11.9624	28.1009	6.7	7
Medium	9.325	1.48285	2.53978	71.1425	15.9019	27.2362	5.5	12
Medium	7.43	0.857	2.09346	53.39	11.5343	28.1758	2.4	9
Medium	8.32	0.9275	2.29569	64.515	11.1478	27.5924	4.3	6
Small	5.438	0.64368	1.47964	39.6413	11.8367	27.2092	0	10
Small	7.02	0.85325	1.77827	65.4375	12.1546	25.3314	4.5	8
Small	12.7045	1.34024	3.94604	72.82625	10.5493	31.0602	5.7	8

*MPP calculated from ration, without considering needs for pregnancy

18% for early and mid-lactation (Moran, 2005)

Feeding strategies

Almost every farm fed their dairy cows differently. Industrial by-products were mixed with water before feeding their cows. However, the frequency and freshness of the mix differed. Some farms prepared the mix once weekly and fed every day from it. Others prepared the mix daily, others every 2 days. Some of the farms added straw to the mix, others did not.

The feeding sequence during the day differed by farm as shown in Table 7. 44% of the farm milked in the morning before feeding. The chronology between concentrate and hay feeding differed: 57% fed concentrates before feeding hay or other forages.

All farms except one allowed the animal a dry period and stopped milking. But only 30% of the farms made a diet change to cover the nutritional needs of dry cows adequately.

Demonstration result

Two cows from a selected farm were fed with 10 kg/day/cow of either matured or young elephant grass (EG) twice a day for 5 days. The trial started with 5 days of feeding on matured elephant grass, followed by 5 days of young elephant grass and again 5 days of mature

Table 7. Chronology of daily feeding activity

Farm size	Feeding activity							
Large	Milking	Concentrate	Hay	Grass	Hay	Milking	Concentrate	Hay
Large	Milking	Brewery by product	Straw	Concentrate	Vegetables	Brewery by-products	Concentrate	Milking
Medium	Hay	Milking	Concentrate	Hay	Milking	Concentrate		
Medium	Milking	Concentrate	Water	Hay	Milking	Concentrate	Hay	
Medium	Hay	Milking	Concentrate	Water	Enset	Milking	Hay	Water
Medium	Milking	Concentrate	Hay	Grazing	Milking	Concentrate	Hay	
Medium	Milking	Hay	Water	Grazing	Milking	Water	Hay	
Medium	Hay	Milking	Concentrate	Grazing	Hay	Concentrate	Milking	Hay
Medium	Milking	Concentrate	Hay	Water	Milking	Concentrate	Hay	Water
Medium	Concentrate	Milking	Hay	Water	Straw	Milking	Hay	Water
Medium	Concentrate	Milking	Hay	Water	Straw	Milking	Hay	Water
Small	Milking	Concentrate	Hay	Water	Hay	Milking	Concentrate	Hay
Small	Concentrate	Milking	Hay	Water	Grazing	Milking	Hay/grass	
Small	Hay	Milking	Concentrate	Water	Hay	Concentrate	Water	Milking

Table 8. Impact of feeding young elephant grass (*Pennisetum purpureum*) on milk production (a demonstration)

Animal	Milk yield (lt/day) while feeding mature EG	Milk yield (lt/day) while feeding young EG	Milk yield (lt/day) while feeding mature EG
Cow 1	22.33	23.6	23.2
Cow 2	21.9	22.4	21.8

Challenges related to fodder

Quality

Fodder quality was not assessed by farmers upon purchase. Over half of the farms (N=9; 53%) had fodder of bad to very bad quality (e.g. too old, containing mold) (Figure 2), which included 3 out of the 4 small farms (75%). There was a statistical significance of fodder quality by farm size (p: 0.015). Only large farms had good to very good quality fodder (N=4; 23.5%).

Availability and storage place

Most fodder availability varied with seasons. Fresh grass was mainly available during and after rainy seasons. Urban and peri-urban dairy farms purchased hay once a year after harvest in November-December directly from small holders in the countryside but usually through middlemen who adjust the prices as they wish. Hay is usually stored for an entire year. Farms are often low on hay towards the end of the year. Straws and crop residues follow harvesting patterns, being seasonal. Industrial by-products such as oil seed cakes and brewery by-products are found all year round with some exceptions and are purchased on a regular basis (1-2 x per month) hence not requiring long storage time.

There was statistical difference in storage facility quality and farm size (p: 0.001). While all large farms had adequate storage place and facilities (N=4; 23.5%), the study showed that small and many medium farms lacked space and could not store adequately and safely (e.g. access to weather and rodents) for long period of times. The storage quality was assessed as excellent in all large farms, whereas 35.3% of farms (medium and small) had bad quality storage. None of the medium and small farms had good storage capabilities.

Price of fodder

Table 3 shows the price range of the available fodders. Most farms relied entirely on purchasing fodder (roughages, by-products and concentrates). Prices fluctuated with season and thus availability, as well as holidays, use of middlemen who can adjust their price as they wish and transportation. The study found that middlemen are the major reason for the price fluctuation. There is no fixed market price for most of the fodder.

Ownership and knowledge of farmers

Ownership of farms varied: 1 large farm was a government farm, 2 large farms were private-NGO type,

Figure 2. Moldy hay.

2 medium farms were private shared farms with several owners, and 12 were private owners. Ownership type did not play any statistical role. Overall, 11 farmers (64.7%) received their farm knowledge from their family and through own experience accumulated over the years; this included all small farms and the majority of medium farms; 4 owners (23.5%) had an educational background at certificate or diploma levels relevant to farm management. These were all 4 large farms. Two farms (11.8%) had their knowledge from their family but attended addition courses provided occasionally by the kebele on farm husbandry/management. There was a statistical significance between farm size and level of knowledge of owners (p: 0.001).

DISCUSSION

This study of husbandry, feeding resources and feeding practices in dairy farms in and around Addis Ababa highlighted some of the challenges and bottlenecks to improved animal productivity and health, namely i) availability of fodder, ii) fodder quality and iii) feeding management.

Dairy cows require basal roughages (grass and hay) as bulk diet and additional fodders high on protein or energy (concentrates, supplementary feeds) (Van Soest, 1982). In this study, grazing and/or fresh grass was available in only a third of the farms and 2/3 of the farms never fed fresh grass. Grazing and grass availability was season

dependent, available during and after rainy season but hardly available during the dry season (March-June). Large farms cultivated alfalfa (*Medicago sativa*) and/or elephant grass (*Pennisetum purpureum*) but fed them only intermittently to their animals (every 2-3 weeks) and only to selected animals. As a consequence, all dairy farms in the study relied entirely on purchased hay for their main basal roughages. Hay was purchased annually and stored for the entire year on-farm, hence requiring adequate storage facilities. Only the large farms in the study had sufficient good quality and spacious storage facilities. The nutrient content analysis of hay showed that it was comparable to straw quality rather than good quality hay and the hay was moldy and/or old in 70% of the farms. Harvesting stage of the plant, drying duration as well as storage duration are known to affect the nutrient content. Plants at a younger growth stage for instance, contain less fiber and more nutrients (Lounglawan et al., 2014; Tilahun et al., 2017). Although, the small on-farm demonstration should be interpreted with caution since it is not statistically representative, it showed that milk production increased between 0.5 and 1.3 L/day per animal within a period of 5 days if fed younger elephant grass instead of the usually cut mature elephant grass. Farmers producing, harvesting and selling hay have poor knowledge on hay quality and grass is harvested and dried when very mature, hence losing important nutrients. In addition, the long storage time (almost a year) on-farm and contact with weather (sun and rain) add to the loss of nutrients. Rural land in Ethiopia is increasingly converted into crop land to feed the growing human population, and good grass lands are declining dramatically (Tschopp et al., 2010; Amsalu and Addisu, 2014). Grass is often harvested along roads or terrain that is not suitable for crops, hence likely to have an impact on grass quality (personal observation). In recent years, more attention has been given by the Government to fodder production in areas in the country such as Afar (personal communication).

Enset (*Ensete ventricosum*), a monocarpic short-lived drought-tolerant perennial plant is used as a food source for humans and livestock in parts of the country (Alemayehu et al., 2001; Nurfeta et al., 2008). The leaves are used as wrapping material and have high protein content (13%) (Tolera and Said, 1994; Mohammed et al., 2013). They contain more calcium than hay, have a higher digestibility than grass and have a net energy comparable to barley (Van der Honing and Steg, 1984). Enset leaves-as green forage, can be found all year round for free in markets and farmers only have to pay for transportation (100 birr (5 USD) for the truck). Despite this readily available cheap fodder source in Addis markets, only 2 farmers fed their animals with it.

Supplementation of additional feeds to cover protein and/or energy needs varied by farm size (Figure 1) with the smallest variety found in small farms. The bulk of these feeds are “homemade” with locally available feed and are often seasonal and costly (Table 3). The major supplemental feed were wheat bran, cotton and nough seed (*Guizotia abyssinica*) cake, brewery by-products and straw (pea, wheat). Cotton and nough seed cake are high on energy and protein and were given by 64.7% of the farms. The use of molasses is often encouraged as it provides energy necessary for microbe activity in the rumen and improves palatability of rations (Van Soest, 1982). In this study, only 4 farms provided their animals with molasses; 3 of them were large farms. Molasses are available from sugar factories that are usually found in locations at lower altitudes (e.g. Adama and Metahara). This requires some logistics since the farmer has to drive there to collect the molasses.

An estimation of the milk production potential (MPP) of the rations distributed to the dairy cows (Table 6) indicated that the maximum MPP was 14.5 L. Farmers generally overestimated the daily milk production when reporting in interviews. Moreover, many rations were not balanced, they were too high on fiber, with a crude protein content below the recommended 14 to 18% for small breeds to allow proper rumen function (Van Soest, 1982) for early and mid-lactation, respectively (10 farms; 58.8%). However, more recent research indicates that the CP content of the ration can be decreased as low as 12% without affecting milk production in low producing dairy cows (Aschemann et al., 2012). Nevertheless, 7 farms (41%) were below the 12% hence their diet having a likely impact on milk production. MPP was linked with farm size. MPP using the rations given showed a mean 12.67 L/day/animal (SD=2.19) for large farms, a mean of 6.68 L/day/animal (SD=2.16) for medium farms, and a mean 5.7 L/day/animal (SD=3) for small farms. Large farms were shown to have better feeding practice and feeding resource which was reflected in the higher MPP.

Milk performance is tightly linked to fertility performance. Fertility is also a high energy demanding process. Feeding animals inadequately will lead to fertility problems (poor heat, poor conception rate) as observed in most of the study farms (data not shown). The ration given in the study showed clearly a lack of energy and protein for proper milk production and fertility performance.

Performance and health of a dairy cow depend very much on adequate rumen function. The latter is affected by various factors such as fodder type and quality, frequency of feeding (the more often an animal is fed, the least pH variation is seen in the rumen), the size of the grains and fibers (too small particles lead to acidosis), and the feeding sequence (hay before concentrates) (Slyter et al., 1976; Yang et al., 2001; Le Liboux and Peyraud, 1999; Macleod et al., 1994). The study showed overall that, farmers fed between 3 and 6 meals per day (as compared to the recommended 12 meals a day or *ad libitum* feeding for dairy cows) and over half of the farmers fed concentrates before feeding hay/forage. This feeding strategy likely leads to poor rumen function with

high pH variation, and risk of acidosis, which ultimately impacts on milk performance and health in general.

All small and medium farms were under-watering their animals. A dairy cross needs about 45-50 L/day for maintenance and 1.5 L extra for each liter milk produced (Murphy, 1992). An animal that produces about 10 L/day as in our study would require at least 60 liter water per day. In average, small and medium farms gave 23.3 and 42.5 L/day, respectively. This severely impacts on milk production and risk of chronic dehydration. The reason lies probably on the lack of knowledge from farmers on animal requirements, existing shortage of water, and bucket drinking logistics which is time consuming and hard work for staff.

All small farms and some of the medium farms showed the poorest animal management and husbandry. Knowledge on the physiology of the rumen and the impacts of fodder types and feeding strategies is crucial in order to keep dairy animals healthy and meet their productivity potential. This study showed that this knowledge is lacking in small and medium farms. This is ultimately reflected by the level of training received. This study showed that all small farms and most of the medium farm owners have had no training in dairy farming. Their knowledge came from own experience obtained over the years and knowledge passed down by family members. In contrast, all large farm owners/ managers had educational backgrounds at certificate or diploma level relevant to dairy farm management. Kebeles are regularly offering training courses for farmers. However, only 2 farmers attended some of these courses.

Since fodder availability is a major constraint due to seasonal availability and high costs, it is even more important that farmers manage the feeding by supplying all nutritional requirements to maintain animal health and performance according to animal outputs such as maintenance, growth, lactation and reproduction optimally in a most cost-efficient way. Lactation can be divided into 3 periods (Tyrell, 2005; Broster and Strickland, 1977; Johnson,1984): a) Lactation peaks during the first 100 days (negative energy balance), requiring optimal feeding for good rumination and high protein supply (17 to 19%) for milk production; b) lactation plateaus that starts decreasing in mid-lactation phase (100 to 200 days). The aim is to keep the production high as long as possible. Dry matter intake is to be maximized with now lower protein supply (15 to 17%); c) decreased lactation to termination, with decreased feed intake. In this phase, protein and energy supply is no more critical and cheap rations can be provided. Hence, targeted feeding that focuses on the three first lactation months can be more cost-effective, and will provide a good milk production and better fertility. Under-nutrition in the early phase will negatively impact on the rest of the lactation (Lukuyu et al., 2011). In Kenya, feeding high concentrated feed in early lactation was shown to increase the milk production by 20% (Romney et al., 2000). Whereas, keeping the same feeding regime throughout the lactation, as seen in this study, particularly in the last lactation phase, will be too costly for the animal need and a waste of scarce feeding resources.

Conclusion

Urban dairy farms are facing multiple challenges to maintain and improve animal productivity. This study showed that poor feeding management (poor feed resources, poor fodder quality which lack protein and energy, and wrong feeding strategies) is likely a key factor for poor milk productivity, fertility and health problems. In addition, poor storage quality (e.g. accessible to rain, rodent urine and feces) led to further deterioration of fodder quality. The contamination of milk and dairy feeds by toxins due to poor feed storage and mold accumulation, is a major problem in the Greater Addis Ababa milk shed with potential public health impacts (Yitbarek and Tamir, 2013; Gizachew et al., 2016). Except large farms, knowledge on dairy husbandry and management was lacking. Training of small holder dairy farmers is crucial so that they can assess good quality forages on purchase, optimize feeding rations per lactation stage so as to maximize milk productivity in early lactation and save costs during late lactations. This strategy is even more relevant in the context of scarce, seasonally dependent and costly fodder as seen in Ethiopia. Strategies should be developed to overcome the issue of seasonal availability of fodder, their high costs and poor quality so as to develop a good quality fodder value chain or on-farm forage production. Hay farmers should be trained on production of good quality hay.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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