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Comparative evaluation of milk yield and reproductive performances of dairy cows under smallholders' and large–scale management in Central Ethiopia

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Comparative mik production and postpartum reproductive performances of Holstein Friesian cows under smallholder and large scale farmers' management was monitored in central Rift Valley of Oromia, Ethiopia. This study was conducted in three purposively selected districts of Arsi Negelle, Ziway, and Lume in Eastern Shoa Zone. Three large scale peri-urban farms having 170 to 195 and 21 small scale urban farms having 1 to 10 heads of dairy animals were identified during the initial exploratory survey. Based on the willingness of the farm owners, the presence of dairy cows of graded Holstein Friesian genotype, known parity and stage of pregnancy of the three large scale farms as a whole and 12 randomly selected small scale farms were considered for monitoring and data collection. A total of 59 animals from large scale (45 animals with average ± standard body weight 427±42 kg) and small scale (14 animals with average ± standard body weight 363±16 kg) were used for 28 weeks of data collection. Significantly (p<0.001) higher milk yield was recorded on large scale farms than on the small scale farms. The reproductive parameters measured were not statistically differed between farm scales. Although, the estimated amounts of crude protein and metabolizable energy consumed by animals were above requirements for the observed level of milk output, the productivity of animals in both farm scales were below their genetic potential particularly that of small scale farms were critically low even than other developing coutries with similar environment elsewhere. The quality of dietary nutrients in terms of the proportion of rumen degradable to undegradable protein sources, structural and non structural carbohydrate and sources of essential minerals needs further assessment for both farm scales.

Key words: Farm size, comparative, nutrients, intake, milk yield, reproduction.

INTRODUCTION

Inadequate and unbalanced nutrient supply is one of the major technical constraints of urban and peri-urban dairy production systems in Ethiopia (Abaye et al., 1991; Goshu and Mekonen, 1997). Dairy farms rely on varieties of feed materials. Feed resource markets provide primarily native grass hay, grain milling by-products and oil seed cakes to urban and peri-urban dairy producers. They also supply commercial mixed concentrates made up of mill by-products (Staal and Shapiro, 1996). Purchased crop residues are also important basal feed resources for small-scale farms in the secondary towns. Generally, the provision of feeds for dairy animals is based on availability than nutrient requirement for a particular productive state of animals.

Conserved native grass hay (mainly composed of *Digitaria decombens, Eragirostis pilosa, Trifolium repens*

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and Trifolium prantense), agro-industrial by-products and commercially formulated concentrate rations are the major feed resources used (Azage and Alemu, 1998) in the urban and peri-urban dairy production systems. However, there is no practice and skill of using nutritionally balanced concentrate diet in these production systems (Staal and Shapiro, 1996). In addition, there is no quality controlling system to regulate the nutrient compositions of commercially formulated concentrate in the way it can fulfill the nutrient requirements of dairy animals in different productive states. This can be one of the major factors to limit the expression of genetic potentials of exotic dairy cattle.

Generally, documented information on the nutrient composition of the available feed resources and its influences on the productive and reproductive potential of urban and peri-urban dairy farms are also limited and needs assessment.

MATERIALS AND METHODS

Study area

This study was conducted in the Central Rift Valley (CRV) of Oromia, at Arsi Negelle, Ziway, Wonji Kuriftu and Lume districts of East Shoa Zone. East Shoa Zone (Figure 1) is located between 38°00'E to 40°00'E longitude and 7°00'N to 9°00'N latitude. It is characterized with different altitude ranges of 1550 to 1900 meters above sea level and average minimum and maximum temperature of 20 and 27°C respectively. It has an erratic and unreliable rainfall, ranging from 500 to 900 mm per year.

Sampling and animal management

A rapid exploratory survey was undertaken to identify and locate the existing large and small scale dairy farms in the urban and peri-urban centers of the study area. Based on the willingness of the farm owners, the presence of dairy cows of graded Holstein-Friesian genotype, known parity and stage of pregnancy, 3 large peri-urban farms having 170 to 195 heads of dairy animals and 21 small scale urban farmers in the secondary towns having 1 to 10 heads of cattle were identified.

The farms were categorized based on the existing herd size as small scale (≤10 animals) and large scale (>10 animals). Accordingly, the three large scale farms and 12 randomly selected smallholder farmers were considered. A total of 59 animals from both large scale (45 animals with 426±85 kg average body weight) and small scale (14 animals with 363±78.5 kg average body weight) with the parity ranging from 1 to 6 and in the last trimester of pregnancy were used for data collection. Animals in different parities were classified as early parity (1 to 2 lactations) and advanced parity (3 to 6 lactations).

In the urban small scale production system the animals were entirely confined at home utilizing whatever space is available in the residential compounds. There were no sufficient exercising areas for animals. Animal houses and feeding facilities on small scale farms were poor relative to that of large scale farms. In the peri-urban large scale production sub-units animals were housed in sheds with well ventilated corrugated metal sheet roof and cemented floors. Their major basal feed sources was based on purchased or very few harvested native grass hay. Green feeds of alfalfa and elephant grass were also used.

Data collection

Data collection was started from about one week postpartum. The utilization of available feed resources and daily milk yield of each selected farm was monitored and recorded every five days for 28 weeks. Daily milk yield of individual animal was monitored and recorded for both AM and PM using portable spring balance. The amount and type of feeds offered to individual animal was also weighed and recorded for each monitoring date. Both daily feed intake and milk yield for none collection days were estimated from average values of the preceding measurements.

Accordingly the refusal of any feed type offered was weighed and recorded. The amount of daily nutrient intake over a given period was estimated by multiplying the nutrient content of the feeds (per kg dry matter) by the daily dry matter intake of the respective feed. Dry feed samples from each farm were collected fortnightly and bulked. They were thoroughly mixed, sub sampled and delivered to International Livestock Research Institute (ILRI) laboratory for chemical analysis.

On the large scale farms, any signs of estrus manifestation was visually observed and recorded by barn attendants and the veterinarian daily in the morning and afternoon. On the small scale farms the enumerators assigned for data recording visually visited the farms and the farmers oriented to report any sign of estrus recorded accordingly. In both cases mating practice was by artificial insemination (AI). However, on the small scale farms several skipped mating were observed due to shortage of AI facilities and/or unavailability of AI technicians.

Chemical analysis

Feeds were analyzed for dry matter (DM), organic matter (OM) and crude protein (CP) using standard procedures of AOAC (1990). Neutral detergent fiber (NDF) was determined as described by Van Soest and Robertson (1985). The *in vitro* organic matter digestibility (IVOMD) was determined using the procedures described by Tilley and Terry (1963). Metabolizable energy (ME) content (MJ/kg DM) of feeds was estimated from *in vitro* organic matter digestibility (IVOMD (g/kg DM) × 0.016) as suggested by McDonald et al. (1988) and Barber et al. (1984). Metabolizable energy intake (MEI) was estimated by multiplying dry matter intake (DMI) of the feeds with the values of their respective energy concentration, that is, MEI (MJ/day) = DMI (kg/day) x ME (MJ/kg DM) according to Kearl (1982) and MAFF (1985). Calcium and sodium contents of the feeds were analyzed using atomic absorption spectrophotometers according to Perkins (1982), and phosphorus content was determined using auto analyzer of AOAC (1990). The daily crude protein (CP) and ME requirement for the animals was estimated based on actual average daily milk yield and fat content according to NRC (1989) recommendation.

Statistical analysis

Data on daily milk yield, milk compositions, postpartum reproductive efficiencies and nutrient intake were analyzed for farm scale, parity class and lactation period differences using the General Linear Model and multivariate analysis procedure of SPSS (1997). Mean differences between subjects under study were tested by pair-wise comparison and least significant difference (LSD) method. Since all the parameters measred were not significantly affected by parity it was excluded from the model.

Table 1. Means chemical compositions of available feed resources for Holstein Friesian cows in small scale farms of central Rift Valley, Oromia.

Feed types	DM	%DM								
		CP	ME (MJ/kg)	NDF	EE	Ash	IVOMD	Ca	P	Na
Grass hay	91	8.68	7.12	75.34	1.44	10.33	46.54	0.40	0.18	0.01
Wheat straw	92	2.56	5.66	81.58	0.93	8.21	36.33	0.09	0.05	0.01
Maize stover	91	5.63	8.74	81.24	0.69	8.21	55.30	0.35	0.10	0.02
Tef straw	92	3.75	6.04	83.49	1.13	6.64	38.63	0.17	0.08	0.01
Haricot bean straw	91	5.19	6.66	70.95	0.65	8.06	42.50	0.18	0.05	0.01
Maize forage	21	10.38	8.90	72.49	1.65	9.22	55.85	0.23	0.15	0.02
Grass forage	13	13.50	9.34	75.45	1.14	12.22	54.54	0.51	0.31	0.02
Nigerseed cake	91	29.75	10.31	36.43	6.22	10.91	58.07	0.69	0.99	0.00
Linseed cake	90	28.81	13.40	37.78	8.07	8.47	68.40	0.51	0.50	0.02
Cottonseed cake	90	22.31	12.06	48.73	6.63	5.56	47.50	0.19	0.74	0.01
Wheat bran	88	17.06	11.63	38.44	4.55	4.36	72.44	0.11	1.00	0.01
Atala[c]	13	21.40	11.00	57.22	-	4.02	69.00	0.61	0.59	0.00
Mixed concentrate	89	22.06	-	36.74	5.87	6.12	64.91	0.28	1.05	0.00

[c] Local brewers grain residue.

Table 2. Chemical compositions of available feed resources for Holstein Friesian cows in large-scale farms of central Rift Valley, Oromia.

Feed types	DM	%DM								
		CP	ME (MJ/kg)	NDF	EE	Ash	IVOMD	Ca	P	Na
Grass hay	92	4.75	5.91	76.90	1.19	8.50	38.94	0.30	0.15	0.05
Alfalfa forage	35	15.50	9.62	56.72	1.91	11.80	53.89	1.04	0.32	0.02
Elephant grass forage	15	13.10	9.02	68.00	1.94	17.06	50.33	0.21	0.28	0.01
Maize forage	35	6.25	9.90	62.32	1.32	9.22	62.24	0.23	0.33	0.00
Grass forage	13	9.13	6.70	75.85	1.37	9.32	44.96	0.43	0.29	0.01
Molasses intake	74	3.50	15.90	-	5.90	18.84	99.69	1.80	0.10	0.26
Mixed concentrate	89	20.16	-	36.62	4.66	7.91	66.56	0.36	1.03	0.42

RESULTS AND DISCUSSION

Chemical compositions of available feed resources

Chemical compositions of available feed resources on small and large-scale farms are presented in Tables 1 and 2 respectively. Crude protein (CP) content of hay was higher (8.7% DM) in small scale farms than in large scale farms, which may be due to proper harvesting time and preservation methods. In large scale farms, the hay purchased may be harvested after being over matured and exposed to sun for longer time as opposed to that in small scale farms.

In both small and large scale farms, Ca, P and Na contents of hay were deficient for dairy cattle requirement of 0.48 to 0.77, 0.25 to 0.48 and 0.06 to 0.25 respectively as suggested by McDowell (1997). Crop residues were used only in small scale farms (Table 1) and all types of crop residues were deficient in CP, Ca, P and Na contents, and lower in IVOMD and higher in NDF contents. This was consistent with reports of Kabaija and Little (1989) in which levels of essential minerals in most commonly used fibrous feed resources were reported to be deficient to marginal.

Among the maize and native grass forages used in both farm scales, grass forage had sufficient Ca content in small scale farms (Table 1) while it was deficient in large sale farms (Table 2). Both forage types were deficient in P and Na contents in both farm scales. The variation in mineral compositions of grass forages may be due to variations in species compositions, soil types on which the forages were grown and stages of maturity at harvesting (Chesworth and Guerin, 1992).

Agro-industrial by-products and non-conventional feed resource of homemade liquor residue (atala) were used only in small scale farms (Table 1). Nougseed cake and linseed cake were sufficient in Ca and P content but deficient in Na contents and this agrees with Solomon

Table 3. Mean daily feeds and nutrient intake of Holstein Friesian cows under two different farmers' management scales in central Rift Valley.

Daily nutrient intake	Farm scales		SE	p
	Small	Large		
Number of animals	14	45		
Total DM intake (kg/day)	11.4	15.8	0.47	***
Roughage	4.9	6.3	0.33	**
Supplement	6.5	9.5	0.44	***
Total CP intake (g/day)	1704	2343	123..00	***
Roughage	259	477	45.85	**
Supplement	1445	1886	104.63	**
CP intake (%DMI)	14.5	15.4	0.59	NS
Total ME intake (MJ/day)	115	141	5.66	**
Roughage	34	41	2.26	*
Supplement	81	100	6.31	*
NDF intake (%DMI)	45.21	49.90	2.35	NS
EE intake (%DMI)	4.2	3.4	0.14	***
Roughage NDF (% total NDF)	71	53	2.26	***
Ca intake (%DMI)	0.40	0.43	0.02	NS
P intake (%DMI)	0.48	0.77	0.04	***
Na intake (%DMI)	0.03	0.26	0.001	**
CP requirement (g/day/head)	1238	1696	89.00	-
ME requirement (MJ/day/head)	103	133	3.78	-

***=p<0.001; **=p<0.01; *=p<0.05. NS, non significant; CP and ME Requirements were estimated based on the actual milk yield (kg/d) and body weights of animals (NRC, 1989).

(1992) who reported that locally produced oil seed cakes were deficient in Ca and Na contents, but sufficient in P, K and Mg contents. Cottonseed cake and wheat bran were deficient in Ca and Na contents but sufficient in P content. The mixed concentrate used was sufficient in CP, ME and P contents in both farm scales. But it was deficient in Ca and Na in small scale farms, while in large scale farms it was deficient in Ca but sufficient in Na content. The low Ca and Na content of concentrate diets in small scale farms was due to the fact that they used mainly the ingredients of wheat bran and nougseed cake or linseed cake which are both deficient in these mineral elements. However, large scale farms used reasonably sufficient common salt to supply sufficient Na but did not consider supplements for Ca sources such as limestone. Some of the small scale farmers used cereal crop residues after soaking them with home-made brewers' grain by-products. It was observed that soaking tef and wheat straws with brewer's grain by product substantially increased the CP, ME, Ca compositions and IVOMD of the feeds (Table 1).

Feeds and nutrient intake

Daily dry matter and nutrient intake for small and large scale dairy farms is presented in Table 3. Significant differences were observed between the large and small scale farms in daily intake of DM, CP, ether extract (EE), P ($p<0.001$), ME, and Na ($p<0.01$). Animals on the large scale farms had higher intake of DM (39%), CP (38%), ME (23%), P (60%) and Na (33%) than those on small scale farms. Dietary calcium intake (%DMI) for animals in small scale farms was below the recommended range (0.43 to 0.77% DMI) of NRC (1989) while that of large scale farms was marginal. The intake of P was within the recommended marginal level of 0.33 to 0.48% of DMI for small scale farms while it was sufficiently higher for animals on the large scale farms.

The ratios of Ca: P was 0.8:1 and 0.6:1 in small scale and large scale farms respectively, while the recommended optimum level was 1: to 2:1 (McDowell et al., 1983). Dietary sodium intake was critically below the required level of 0.18% (NRC 1989) in small scale farms, but sufficiently high in large scale farms. Preserved crop residues of different types (maize stover, tef straw, wheat straw and haricot bean) were the major basal feed base for small scale farms in this study. These crop residues were low in digestible matter, nitrogen and true protein content which may limit the intake of DM and other nutrients. Chenost and Sansoucy (1991) and Chesworth and Guérin (1992) reported that voluntary feed intake of ruminants essentially depends on the rate of degradation of its digestible matter. About 43% of the total DM

Table 4. Mean daily milk yield, milk compositions and reproductive efficiency of Holstein Friesian cows under two farm scales.

Parameter	Farm scales		SE	p
	Small	Large		
Number of animals	14	45		
Milk yield (kg)	11.5	15.8	0.73	***
FC milk yield (kg)[a]	11.1	14.7	0.67	***
Calving to first sign of estrus (days)	96	115	14.60	NS
Days open	171	148	23.50	NS
Services/conception	1.6	2.1	0.24	NS

***=p<0.001; [a]FC = fat corrected.

consumed by animals on the small scale farms was roughage feed as compared to 38.6% on the large scale farms. Similarly about 71% of NDF intake of animals on the small scale farms was roughage feeds as compared to 53% on the large scale farms indicating that the smallhoder farmers mainly depend on poor quality roughages for their dairy animals.

Since the potential intake of forage is inversely related to its NDF content, the DM intake and consequently that of other nutrients were limited for animals in small scale farms.The utilization of agro-industrial by-products such as nougseed cake (*Guizota abyssinica*), linseed cake, cotton seed cake and wheat bran was minimal (7.76% DMI). A home-made brewer's grain by products (39% DMI) mixed with crop residues or alone was also used. Mixed concentrate in the daily dietary DM intake of animals in small scale farms was only 9.6%.

Milk yield and reproductive efficiency

The mean daily milk yield and postpartum reproductive efficiencies of Holstein Friesian cows on large and small scale farms are presented in Table 4. Difference in actual and fat corrected (FC) daily milk yield was highly significant ($p<0.001$) between the two farm scales. There were higher daily milk yield and FC milk yield (15.8 and 14.7 kg respectively) on the large scale farms than on small scale farms (11.5 and 11.1 kg respectively). The higher milk yield of animals on large scale farms may be attributed to higher intake of DM, CP, ME, Ca and P relative to the small scale farms.

It was also observed that smallholder farmers maily depend on poor quality roughages as a basal diets. With high technological inputs in terms of feeding management and health care milk production per cow is extremely very high than with low inputs (Leng, 1991). The utilization of conserved hay, green forages and mixed concentrate on large scale farms were about 26.6, 12 and 59% of daily DM intake respectively as compared to only 6.4, 5.4 and 9.6% respectively on small scale farms. This also reflects that the productivity of ruminants is influenced primarily by quantity and quality of feed intake (Preston and Leng, 1987).

The quantity of CP and ME may not be the limiting factors for low performances of the animals under this study. Possible reasons for the low milk yield performances of animals in small scale farms may be due to poor nutritional qualities of crop residues used (about 36.4% of daily DM intake), the CP intake from home-made liquor residues which was about 39% of daily DM intake and provided about 76% of the total CP intake may be heat damaged during the long time boiling for alcohol distillation. Therefore, its CP may be unusable or poorly digested in the lower digestive tract as well as in the rumen. This may result in too low ammonia levels in the rumen which can not meet the requirement for efficient growth of rumen micro-organisms (Perston and Leng, 1987). Sources of supplemental CP are an important factor to influence the response of animals, due to their variation in type and levels of essential amino acid (EAA) contents (Christensen et al., 1993).

In addition, the minimal and inconsistent use of protein sources from mixed concentrate and agro-industrial by-products by small scale farmers may result in lower nutrient intake and consequently low productivity of the animals. On both small and large farm scales the ratio of Ca: P was observed to be very low (0.83:1 and 0.56:1 respectively). McDowell et al. (1983) reported that with dietary ratios below 1:1 and over 7:1 growth and feed efficiency decreased significantly. Simon (2005) in Tanzania reported that, there were high milk yield in large scale farms compared to smallholder farms. Differences in milk production between the two management systems were attributed mainly to the level of management. Like small scale farmers in other developing countries (Leng, 1991), smallholder farmers in this study could not be able to select quality basal diet, than using whatever was available at no or low cost.

The days from calving to first estrus (CFE), days open (DO) and the number of services per conception (S/C) was not significantly ($p>0.05$) different between the farm scales (Table 4). But the value of DO (171 days) on small scale farms was longer than on the large scale farms

(148 days). This is due to lack of regular AI services and several skipped services were observed. The days to first estrus (115 days) and SPC (2.1) were higher on the large scale farms than on the smallholder farms, (96 and 1.6 respectively), which may be due to poor heat detection practices on large scale farms. Since the number of animals on small scale farms was very few, farmers could be able to closely observe estrus manifestation of their animals than the large scale farms where there was relatively large number of animals and could not be easy to closely observe estrus manifestation of individual animal.

It was observed that commercial animal feed marking firms could not consider the inclusion of Ca sources which is demanding for the productive and reproductive performances of dairy cattle. In addition, the mixed commercial concentrate as well as the milling by-products of cereal brans were more of fiber and lack grains which can provide soluable carbohydrates. The protein source used was entirely negerseed cake (*G. abyssinica*) and there may be limited rumen by-pass protein sources.

Conclusion

Although, the estimated amounts of crude protein and metabolizable energy consumed by animals were above requirements for the observed level of milk output, the productivity of animals in both farm scales were below their genetic potential particularly that of small scale farms were critically lower than even those in other developing coutries with similar environment elsewhere. The quality of dietary nutrients in terms of the proportion of rumen degradable to undegradable protein sources, structural and non structural carbohydrate and sources of essential minerals needs further assessment for both farm scales.

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