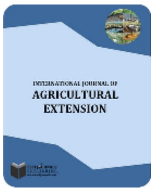

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INFLUENCE OF ON-FARM FEED FORMULATIONS AND HYGIENE INTERVENTIONS ON MILK YIELD AND QUALITY IN SMALLHOLDER DAIRY FARMS IN KENYA

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A B S T R A C T

This study aimed at improving smallholders' feeding and milk hygiene practices in order to increase milk production and improve its quality. A participatory action research was designed with focus group discussions, prioritization of farm challenges, training sessions and interventions in feeding and milk hygiene. Identification of challenges revealed low milk prices, poor breeds and feed unavailability as priority challenges. Feeding intervention was selected by the platform because of feasibility and farmers expressed need to address low production. Milk quality had low priority but was selected because of farmers' willingness to learn about recommended practices. Identification of fodder crops using the Feed Evaluation Assessment Tool (FEAST) revealed that, in order of importance, peri-urban farms utilized more purchased feeds and collected fodder while rural farms utilized more pasture grazing and purchased feed. Feeding interventions increased milk production by 20% but hygiene intervention did not improve milk quality. Introduction of knowledge on proper feed management and ration formulation through participatory research is therefore an opportunity to improve production, income and food security in smallholder herds. Although milk quality is often prioritized in dairy research in smallholder farms, farmers are more interested in increasing production for higher income, hence interest in feeding.

Keywords: Dairy cows; FEAST; Urea treated crop residues, Participatory action research; Napier grass silage

INTRODUCTION

Food Smallholder dairy cattle farmers supply more than 75% of total milk production in Kenya. They are characterized by low milk output and low quality (Bebe *et al.,* 2003; Lore *et al*., 2005). Feed types, quality and quantity are major contributors to milk production (Wanapat *et al.,* 2017). Diets with dry matter content lower than 11Kg/cow/day, energy lower than 6.28 MJ/Kg and crude protein lower than 13% are important explanations for low milk production in smallholder farms (Kashongwe *et al.,* 2017; Njarui *et al.*, 2011). They reported the use of natural pastures with or without supplementation by forages and concentrates in rural farms, the importance of purchased feeds and crop residues in the peri-urban (Kashongwe *et al.*, 2017). These feeding practices were not sufficient to support high milk production. Milk hygiene practices on the other hand consist of hygiene of the udder, the milking person, the equipment and milking environment (Lore *et al*., 2006). These practices when not adequately applied increase the risk of contamination by pathogens such as Staphylococcus aureus, causing mastitis and reducing not only milk quality but also milk production (Kashongwe *et al.,* 2017). Interventions to increase production and quality are numerous (Lukuyu *et al.,* 2012; Lore *et al.,* 2005; Kurwijila, 2006). Despite the efforts of bringing improved practices/ technologies to farmers, uptake remains low (Omondi *et al.,* 2017). This is possibly because of limited innovation capacity in accessing information, technology or inability to invest in recommended innovative technology. Participatory action research together with collaborative learning could be an alternative to foster better understanding and contextualization of innovations to farmers' needs and priorities (Mahra *et al.,* 2015; Musvoto *et al.*, 2015; Restrepo *et al.*, 2016). Mahra *et al.* (2015) used participatory rural appraisal and found that chances of adoption of innovation or recommended practices are increased when local problems and available resources

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are identified with the communities. This suggests that promoting innovations relevant in low agricultural input systems requires that the innovation be indigenously generated through research processes that harness and integrate knowledge and information in stakeholder interaction platform (Musvoto *et al.*, 2015). This study therefore used participatory action research to develop with farmer groups contextualized options to improve milk production and quality. The study aimed at developing and testing contextualized feeding, hygienic milking and handling interventions for smallholder dairy farmers to bridge the knowledge gap in on-farm application of recommended practices.

METHODOLOGY

Development of research agenda: The study was conducted in Nakuru County, Kenya for the sample of rural and peri-urban smallholder herds. Two farmer groups were selected, one from rural (Olenguruone Dairy Farmers' Cooperative) and another from peri-urban (Mukinduri Self-Help Group). Rural farms were sampled in the highlands of Nakuru County in Olenguruone Division located at 80 Km from Nakuru town. They are characterized by free grazing systems for dairy cows and collective marketing of milk due to limited outlets. Peri-urban farmers were sampled in the surrounding of Nakuru town (less than 35 Km) and are characterized by more intensified production systems (zero-grazing and semi zero-grazing). They milk marketing practice is more diverse than rural due to prominence on informal traders (Leksmono *et al.*, 2006).

A participatory action research approach was used where researchers, facilitators and farmers from rural and peri-urban established a research platform. The platform initiated a learning process with focus group discussions and individual farmers' interviews to identify management problems related to dairy farming. These problems were prioritized and possible solutions were suggested to inform draft research agendas for implementation (Figure 1). Sequential on-farm training sessions were conducted by researchers. This was followed by on-farm experiments to fill knowledge gaps expressed by farmers and to assess applicability of suggested interventions in farmers' context. Farmers selected three volunteer members in each location (i.e. rural and peri-urban) to participate in experiments. The criteria for selection were provision of at least 2 lactating cows, existence of facilities (cowshed) and availability of feeds and accessibility of the farm by all farmers of the group. The choice of experimental units, variables and other measurements were made by the platform. This pilot group (3 farmers in rural and 3 farmers in peri-urban) formed the intervention sample while the rest of the beneficiaries (13 farmers in rural and 9 farmers in peri-urban) formed the control (participating) group. Data collection tasks were then distributed within the platform with farmers in charge of record keeping and collection of samples, while researchers organized training sessions and analysis of samples. Figure 1 summarizes the research process developed by researchers and adopted by the platform.

Improved feeding practices: Two feeding interventions were designed in peri-urban and rural smallholder farms to improve nutritive value and utilization of identified available feed resources: Maize stovers in peri-urban farms and Napier grass in rural farms. In peri-urban farms it consisted of improving nutritive value of maize stalks to include in a forage mixture with Napier grass and Lucerne. Maize stalks were abundant in the area from previous planting season. They were chopped manually and spread on a polythene sheet, then 400 g of urea diluted in 5 litres of water were sprinkled on it and mixed thoroughly. The mixture was put in a silage tube (1.5m x 3m) tied to avoid oxygen inclusion and left to incubate for 21 days. After 21 days, the silage tube was opened to allow excess ammonia to escape before mixing with little molasses (0.1 kg/L water). Then wilted Napier grass and lucerne were chopped and mixed with treated maize stalks ready for feeding.

Milk composition was determined following standard methods. Feeds analysis included dry matter (D.M.) and crude protein (C.P.) following standard methods (Galyean, 2010). Net energy for lactation (N.E.l) values was obtained from the NRC tables (2001). The proportional composition of peri-urban feeding ration is presented in Table 1.

In rural peripherals, the intervention consisted of silage making with Napier grass harvested early (1 m high) in order to preserve its' nutritive value before it decreases (Manyawu et al., 2003). Napier grass was the most common forage supplement in rural farms during the investigation and farmers mentioned willingness to learn the technique since some of them had tried but never succeeded to make good quality silage. Wilted Napier grass was chopped either manually or using a chaff cutter. Then 1 kg of molasses was diluted in 3 liter of water and sprinkled on 10 kg of Napier grass spread on a plastic sheet. This was mixed thoroughly, put in a silage tube (1.5m x 3m) and tied in a way to exclude oxygen from the mixture. The ensiling process took 21 days, afterward mature silage was ready for feeding. Feeds availability and challenges where assessed using Feed Assessment Tool (FEAST) (ILRI, 2015). The FEAST is a systematic method to assess local feed resource availability and use. It helps in the design of intervention strategies aiming to optimize feed utilization and animal production. It uses both focus group discussion guides and individual farmer assessment of feed resources (ILRI, 2015). Feeding interventions were evaluated by dry matter intake, animal body condition, milk production and milk composition.

Figure 1. Summary of the research process (Adapted from Musvoto *et al.,* 2015).

Table 1. Proportional contribution of feed ingredients used in peri-urban farms.

Feed ingredient	Proportion (%)	N.E.l	C.P. (%/ proportion)
Urea treated maize stalks	28.57	0.41	2.29
Lucerne	21.43	0.26	4.11
Napier grass	21.43	0.50	2.14
Dairy meal	28.57	0.61	6.85
Total	100	1.77	15.40

Improved hygiene milking and handling practices: Unlike feeding intervention, milking and handling hygiene were included because farmers mentioned during focus group discussions, willingness to learn more about recommended practices. Training sessions focused on cleanliness of cowshed, milking person, recommended pre-milking practice, milking routine and post-milking handling of milk. Hygiene interventions were evaluated by milk quality.

Data analysis: Descriptive statistics was used to analyse data from FGDs and individual interviews in SAS v 9.1. The Generalized Linear Model (GLM) procedure of SAS was used to determine the change influenced by the interventions on milk yield and quality by herd category of participants.

RESULTS AND DISCUSSION

Prioritization of challenges and suggested solutions in the smallholder farms: Farmers ranked low milk price a first priority challenge in both rural and peri-urban farms for which their suggested intervention was better access to markets and to market information and milk value addition. Seasonal feed unavailability and poor breed were ranked second and third challenges in rural farms, while they were third and second ranked in peri-urban farms. Farmers suggested purchasing more feeds, growing fodder and feed conservation as solutions in rural farms (Table 2).

The raised challenges are all causes of low milk production, showing farmers' need to improve production. This also confirms findings from FAO, (1990), who reported the unavailability of proper inputs and technical 'know-how' as priority problems at farm level. Based on the challenges mentioned, the platform opted for feed interventions as feasible options for improvement. Value addition of maize stalks was selected in peri-urban, while preservation of Napier grass through silage making was selected in rural. Both feeds were abundant in the areas.

Table 2. Priority challenges and possible solutions in the smallholder farms.

	Smallholder peri-urban		Smallholder rural	
Priority	Challenges	Possible solution	Challenges	Possible solution
1	Low milk prices	Access better markets	Low milk prices	Better market information, Milk value addition
2	Poor breed/ inefficient A.I. services	Outsourcing information and access to better semen	Seasonal feed unavailability	Improve information and knowledge of feed conservation
3	Feed availability	Purchase feed Growing fodder	Poor breeds due to inbreeding	Farmers' sensitization to use A.I. services
4	High costs of salt lick and dairy meal	Get extra cash from off-farm jobs to buy feeds	Diseases outbreak	Vaccinations
5	Low milk production	Change breeds Improve feeding	Animal theft	Security improvements (better fences)

Description of available feed resources in rural and peri-urban: The main crops cultivated in peri-urban were common peas, maize, potatoes and common beans with fodder crops Napier grass, Lucerne, oats and sorghum on small land (0.6 ha and 10% of total farm holding). Dry matter intake was mostly from purchased feeds (50%) in peri-urban and grazing (80%) in rural farms. Collected fodder (35%) and cultivated fodder (8%) was common peri-urban and rural farms respectively (Figure 2). Energy intake followed the same trend as dry matter intake and was mostly from purchased feeds in peri-urban, while grazing was the major contributor in rural farms (Figure 3).

Land holding may be the reason for fodder preferences. Peri-urban farmers have to choose between food crop production and fodder production on the small available land. Rural farmers on the other hand have larger farm sizes (2.1 ha) than peri-urban farms (0.6 ha) which allow them to grow natural pastures and rely on Napier grass as forage supplement. Energy and crude protein intake followed the tendency and were mostly from grazing in rural and from purchased feed and collected fodder in peri-urban.

Feeding experiment: However, before training, farmers experienced high refusals from feeding troughs probably because forages were fed without reducing to an acceptable size of less than 5 cm (Heinrich & Kononoff, 2002). Green fodder such as Napier grass was mostly fed when overgrown at about 2m high, indicative of reduced nutritive value (Wijitfan et al., 2009). Additionally, cows' body condition score (BCS) was 2 and dry matter intake was low in both pilot and control group before intervention either in rural or peri-urban farms. Rural farmers had good knowledge of planting and harvesting forages but availability of these feed resources were said to be affected by seasonality which might have motivated farmers to mention it as second priority challenge (Table 2). A knowledge need in forage preservation arose that was addressed by feeding intervention through training and feeding trials. Training in Napier grass silage making improved in milk yield (+ 19%) (Table 3). The difference in milk fat between cows participating in the experiment (base and intervention) and the control introduced may be due to animal factor (level of production, stage of lactation, breed) (Waldner et al., 2005). Intervention results on the other hand were obtained after subjecting base group to improved diets. The improvement in feed intake (+65%) may explain higher milk yield.

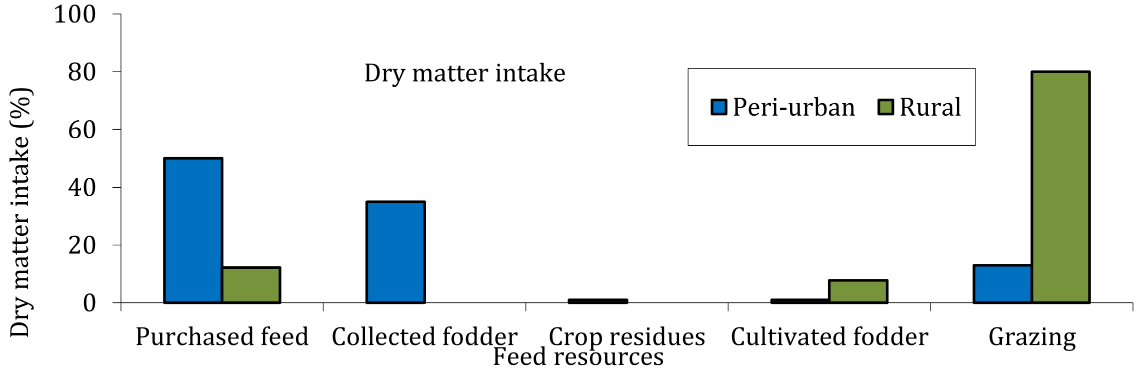

Figure 1. Contribution of available feed resources to dry matter intake in smallholder peri-urban and rural farms.

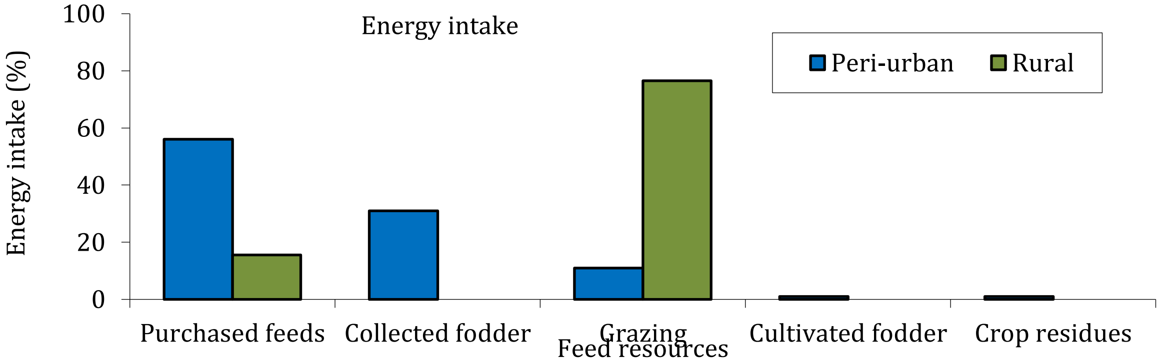

Figure 2. Contribution of available feed resources to energy intake in smallholder peri-urban and rural farms.

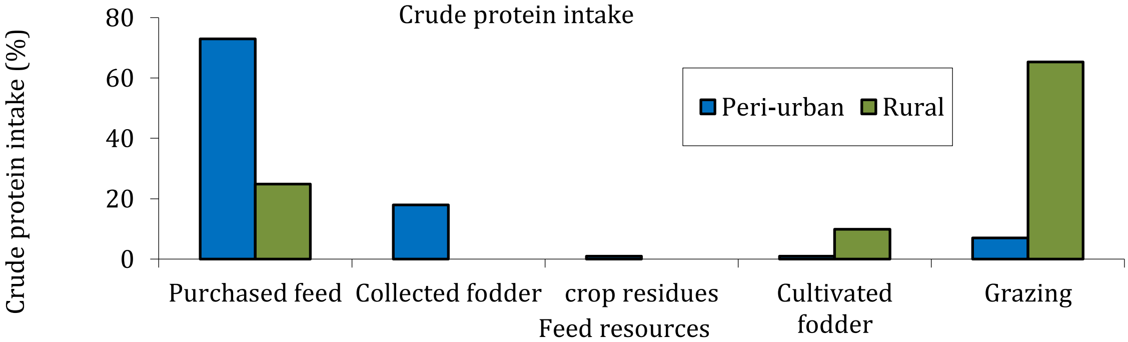

Figure 3. Contribution of available feed resources to crude protein intake in smallholder peri-urban and rural farms.

Table 3. Effects of intervention on feed intake and milk yield in rural farms.

	DMI (Kg)	Feed refusal:	BCS	Milk Yield (Kg)
Control	8.5±0.5	-	2	3.1±0.6
Base	8.5±0.5	-	3	7.3±1.0
Intervention	14±0.7	<5%	3.5	8.7±1.0
% Change				
Intervention vs base	65%	-	-	19%
Intervention vs control	65%	-	-	181%

The feeding intervention in peri-urban farms led to reduction of refusals from feeding troughs achieved by reduction of particle size through chopping forages (Heinrich & Kononoff, 2002) and mixing of green and dry forages. The major sources of dry matter, energy and crude protein were purchased feeds and collected fodder. This constituted a challenge for peri-urban farmers who had to look for off-farm jobs to get money to purchase feeds for their dairy cows (Table 2). Moreover, farmers had plenty of maize stalks from previous planting season which they fed as supplement to green forages. Therefore, focusing on improving nutritive value of maize stalks with urea treatment in peri-urban farms, the training addressed feed cost challenges but also improved performance of cows (20% increase of milk yield). Body condition score (from 2 to 3) and dry matter intake (+108%) were also improved (Table 4).

This is because urea treated crop residues provide higher nitrogen content and higher dry matter degradability (Jabbar *et al.*, 2009). Results from previous studies on the effect of treated crop residues on dairy cows' performance (Jabbar *et al.*, 2009) concur with our findings.

Table 4. Effects of intervention on feed intake and milk yield in peri-urban farms.

	DMI (Kg)	Feed refusals	BCS	Milk yield (Kg)
Control	6±0.1	>50%	2	9.1±2.0
Base	6±0.1	>50%	2	14.6±0.5
Intervention	12.5 ±0.1	<5%	3	17.5±1.4
		% Change		
Intervention vs base	108%	-90%	--	20%
Intervention vs control	108%	-90%	--	92%

Change in milk quality due to milk hygiene interventions in smallholder rural and peri-urban dairy farms: Milk hygiene was included in the training sessions, although not mentioned as a priority challenge. Farmers expressed need for learning about new practices that can improve their milk quality. However, effects of training weren't reflected in milk quality. In pilot farmers, microbial loads were higher after trial (intervention) than before (base) with 6.1 cells/ml log10SCC vs 5.9 cells/ml log10SCC in peri-urban. In rural, log10SCC decreased after trial (6.6 cells/ml vs 5.8 cells/ml) but log TVC increased (3.7 log10 cfu/ml vs 6.5 log10cfu/ml) (Table 5). This shows that despite training on hygiene milking practices and farmers' willingness to learn about practices to improve milk quality, it is not yet a priority for them. Both internal factors such as level of production (milk yield) and feeding (Restrepo *et al.,* 2016), and external factors such as market access and milk price contribute to the low attention paid by farmers on milk quality (Kashongwe *et al.,* 2016).

Table 4. Change in milk quality due to milk hygiene intervention.

	Peri-urban				Rural			
	Base	Intervention	Control	P	Base	Intervention	Control	P
Log10SCC (cells/ml)	5.9 (±0.1)a	6.1 (±0.1)a	6.1 (±0.1)a	0.05	6.6 (±0.2)a	5.8 (±0.2)b	6.1 (±0.2)b	0.003
Log10TVC (cfu/ml)	5.9 (±0.6)a	7.2 (±0.6)a	7.4 (±0.9)a	0.05	3.7 (±1.1)b	6.5 (±1.5)a	7.5 (±1.5)a	0.002
Log10CC (cfu/ml)	1.4 (±0.7)d	7.5 (±0.7)d	2.6 (±0.9)c	<0.001	0.2 (±1.2)b	0.0 (±1.7)b	7.5 (±1.7)a	<0.001
Staphylococcus aureus	Present	Present	Present	--	Absent	Absent	Absent	
Streptococcus .spp	Present	Present	Present	--	Absent	Absent	Present	

Means followed by different letters in superscript are significantly different at 5%.

CONCLUSION AND RECOMMENDATIONS

Contextualized feeding practices introduced in participatory action research contributed to increase milk production. Trainings in milk hygiene did not lead to improvement on milk quality. Using participatory action research to increase uptake of improved feeding practices in smallholder farms, taking into account available resources and context specific challenges, is recommended.

More emphasis on milk quality in extension and training programs using the same approach is needed to raise farmers' awareness of importance of good quality milk for cows and consumers' safety. Milk quality control should be strict to restrict poor quality milk enter the market.

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