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Randomized controlled trial on impacts of dairy meal feeding interventions on early lactation milk production in smallholder dairy farms of Central Kenya

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ABSTRACT

There is limited field-based research and recommendations on the effect of cattle feeding management practices on smallholder dairy farms (SDF) for the growing dairy industry in Kenya. This controlled trial aimed to determine the effect of feeding locally produced dairy meal (DM) on early lactation daily milk production (DMP) on Kenyan SDF, controlling for other factors associated with DMP. Privately owned, recently calved cows ($n = 111$) were randomly assigned to one of three groups of feeding recommendations for DM (meeting predicted DM requirements by: (1) 100%; (2) 50%; or (3) feeding by the farmer's discretion). DM was provided for free to groups 1 and 2 to ensure they had sufficient DM to feed to the recommendations. Data collection on cow and farm characteristics occurred biweekly for a 60-day period post-calving starting in June 2013. A repeated measures multivariable linear regression model was used on the DMP outcome variable. With variability in DM consumption within feeding groups due to variability in DMP, actual DM fed was assessed as an independent variable rather than assigned feeding groups. DMP was positively associated with each kg/day of DM fed (0.53 kg/day), cow weight (0.13 kg/day), feeding DM in the month prior to calving (1.42 kg/day), and feeding high protein forage (0.41 kg/day), and was negatively associated with having mastitis (−0.30 kg/day). In interaction terms, taller cows had higher DMP than shorter cows, whereas heifers (first parity cows) had similar DMP regardless of height. Also, thin cows (2+ parity with body condition score < 2.5 out of 5) produced less milk (1.0 kg/day less) than cows with a better body condition score at calving,whereas thin heifers produced more milk (2.0 kg/day more) than heifers in better body condition—this association is possibly due to a small unrepresentative sample size of heifers. In conclusion, feeding DM in the month prior to calving, improving body condition in cows prior to calving, and enhancing dietary DM and high protein forage were positively associated with DMP in early lactation on Kenyan SDF. In addition there was an association between, taller cows and increased DMP, evidence supporting the importance of educating farmers on good genetic selection and heifer management. These findings will help with future management recommendations for higher DMP on SDF.

1. Introduction

In developing countries, there are an estimated 1.2 billion impoverished people, and 75% of this population live in rural settings and depend on agriculture for their livelihood (FAO, 2014). To alleviate poverty, the FAO suggests that rural economies need to be more diversified, resilient, productive, and environmentally

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sustainable (FAO, 2014). During 2010–2012, poverty contributed to chronic undernourishment of an estimated 870 million people, or 12.5% of the world's population (FAO, 2012). Human health and nutrition can be improved by alleviating poverty through livestock agriculture, which acts as both a source of income and of high quality food (Randolph et al., 2007; Smith et al., 2013). Livestock agriculture can also aid in supporting rural economies by being both productive and environmentally sustainable when managed appropriately (Randolph et al., 2007; Smith et al., 2013).

On smallholder dairy farms (SDF) in developing countries such as Kenya, dairy cattle are an important source of milk for farming families to consume, as well as income through sales of excess milk (VanLeeuwen et al., 2012). Lack of access to resources (such as feed and finances), technology, markets, and supporting organizations leads to lower productivity of SDFs (FAO, 2014). More specifically, many farmers in Sub-Saharan Africa are limited by their lack of knowledge in good animal husbandry and farm management practices, including animal nutrition (Gitau et al., 2001; VanLeeuwen et al., 2012; Nyka et al., 2014). Increased income from enhanced milk sales should follow improved nutrition of lactating dairy cows (Moran, 2005). However, limited field-based research and recommendations exist on the effect of cattle feeding interventions on SDF in Kenya, making it difficult to develop locally appropriate feeding practices to farmers.

Daily milk production on SDF in Nyeri County was reported to range between 5.5 and 9.2 kg/day, without adjusting for stage of lactation (VanLeeuwen et al., 2012; Walton et al., 2012). Despite the low production, SDF account for about 80% of all milk produced by over 3.8 million dairy cattle in Kenya (Wambugu et al., 2011). Despite the dairy farming industry being the largest agricultural sub-sector in Kenya, there is still evidence of under-production on individual SDF (Wambugu et al., 2011).

Zero-grazing farming practices are more common within Central Kenya, where it is more densely populated and farmer ownership of small plots is more common than elsewhere in Kenya (Wambugu et al., 2011). Dairy farms in Central Kenya which employ zero-grazing typically have higher milk production than farms where cattle are grazed, but the profit margin is often lower due to higher costs, so farmers must carefully consider the cost-benefit of feeding concentrates which are the highest cost to farmers (Wambugu, 2011).

The impact of concentrate feeding on milk production is difficult to determine in the field because of the variable quality and quantity of forages fed on SDF, depending upon season, forage management (eg. species, varieties, planting practices, timing of cutting, chopping), income and labour availability (Rufino et al., 2009). On SDF of the Mukurwe-ini Wakulima Dairy Ltd. (MWDL), farmers most commonly feed Napier grass and banana leaves, but also *Desmodium*, *calliandra*, sweet potato vines, other fodders, and hay in lesser amounts (Richards et al., 2015). Sixty-percent of MWDL farmers involved in an observational research study also reported having feed shortages in 2013, contributing to the fluctuating levels of fodder availability and quality (Richards et al., 2015).

In order to evaluate the effect of feeding locally produced DM on early lactation daily milk production (DMP) on Kenyan SDF, a feeding controlled field trial was conducted on MWDL farms.

2. Materials and methods

2.1. Study site and study population

This study was approved by the Research Ethics Board and the Animal Care Committee of the University of Prince Edward Island, the MWDL, and a partner non-governmental organization Farmers Helping Farmers. Signed consent to join the study was obtained from all participants after the project had been fully explained.

The study was carried out in Mukurwe-ini sub-county of Nyeri County, Kenya, with members of the MWDL from June–September 2013 (early cool dry season to late cool dry season). There were over 6000 members of the MWDL in 2013. Mukurwe-ini has an estimated population of 83,932 people as of 2009 and covers 179 km^2 (Kenya National Bureau of Statistics, 2010). Nyeri County is part of Kenya's Eastern Highlands spanning an area of 3337 km^2 (Kenya National Bureau of Statistics, 2010). Mount Kenya is located to the east of Nyeri County at an altitude of 5199 meters, and the Aberdare Range is to the west, peaking at 3999 meters (National Coordination Agency, 2005). The study area is considered part of the humid highlands at an altitude of over 1500 m, with annual rainfall over 1000 mm and humidity >50% (Orodho, 2006). This area is classified as an agro-climatic zone (I–III) that has a high potential for growing crops (Orodho, 2006).

A sample size of 108 farms with a newly calved cow was determined, based on an unpublished pilot study we conducted of DMP in 36 cows in early lactation ranging from 11.6 kg/day in the low DM group to 15.5 kg/day in the high DM group, and an overall standard deviation of 3.0 kg/day. The study included 3 mineral feeding groups (related to reproductive outcomes, not reported here) in addition to the 3 DM feeding groups, therefore 12 cows/group and 9 possible feeding groups led to 108 cows required. To ensure an adequate sample size, 111 farms were enrolled to allow for other potential withdrawals from the study (eg. sold). Farms were contacted and enrolled from a database held by MWDL, consisting of cows that had been artificially inseminated (AI) by MWDL veterinary services between 9 and 10 months prior to the start date of the study. Farms were excluded if they had more than 4 adult cows as these farms were not classified as a typical SDF. Due to small herd sizes, only one cow per farm was enrolled. Farms were all zero-grazing with some form of stall/bedding area, and manger/eating area.

2.2. Study design

This study was a randomized controlled trial with a three level intervention, where random allocation was blocked by cow body condition score (BCS) on the first visit, with BCS categorized as acceptable (≥2.5 out of 5) or low (<2.5 out of 5). Cows ($n = 111$) were enrolled within 7 days of calving to ensure uniformity of stage of lactation. Cows within blocks of thin and acceptable BCSs were randomly allocated to one of the three possible DM feeding groups by 'drawing from a hat' one of the three possible treatment groups. Farmers were not blinded to their treatment group due to the nature of the treatment. Daily feeding recommendations for the 16% protein dairy meal were based on published requirements for maintenance, lactation and weight gain for a 400 kg live weight cow producing milk with a fat content of 4.0% (National Research Council (NRC), 2001), which were the cow parameters commonly observed in our pilot study. For field application, these amounts were estimated using the following formula:

$$\text{Kg DM} = \frac{(\text{Kg DMP} - 5)}{2}$$

This formula approximates National Research Council (NRC) requirements if the following assumptions are made: total daily dry matter intake conforms to NRC requirements for a given live weight and DMP, and the balance of dry matter intake is in the form of freshly harvested vegetative Napier grass at published values (10% crude protein) for nutritional composition (Moran, 2005). Given these assumptions, this formula was found to model NRC requirements satisfactorily over the range of 0–30 kg daily milk yield in our pilot study. The DM was formulated for lactating cows

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