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Relevance of fodder interventions on dairy farms performance in Kenya; A review

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Abstract
The dairy sector is the largest agricultural sub-sector in Kenya, and its share in GDP is approximately 4%. Milk consumption per head of population is one of the highest in Sub-Sahara Africa and stands at 115 litres per person. An estimated 80% of total production comes from smallholder farmers of which about 50% is marketed. Out of this 50%, 25% enters the market as processed milk and value-added milk products. The fodder interventions implemented during Kenya market-led dairy program (KMDP) inception phase confirmed that one of the most important bottlenecks for enhanced competitiveness and growth in dairy sector, is access and availability of quality fodder. This has been achieved through introduction of fodder related intervention which positively influenced milk yield, economic, and reproduction performance of the dairy farms in Kenya. The dairy sector is in agreement that without proper feed and feed rations feeding regimes the genetic potential of the breed remains unlocked, and that good fertility management relies heavily on the animal's health and feeding. The fodder gap in dairy sub-sector has severe impact on cost price of milk, profitability of the farm enterprise and seasonality in milk supply. Improving fodder conservation and utilisation efficiency through high quality forages and alternative feeding practices has shown the potential to increase farmers' income through improved milk yield and nitrogen use efficiency.

Keywords: Commercial fodder producers, cost of production, dairy profits, milk quality, milk yield, nitrogen use efficiency

Introduction
Kenya has a vibrant dairy industry with an estimated value of 4% of gross domestic product (GDP). This vibrancy is anchored on the increasing domestic milk production (averaging 5.3% per year), processing capacity (averaging 7% per year), annual per capita milk consumption (averaging 5.8% per year, currently at 110 litres) and export potential [21]. The sector is in a transition phase from smallholder subsistence farming with on average 3-4 crossbreed cows for home consumption and sales of small quantities of excess milk (5-10 litres per day), to dairy entrepreneurs with dairy as core business [19]. The latter invest in amongst others exotic breeds, improved dairy barns and fodder production and preservation. This segment of dairy farms/farmers is of a varied composition in terms of farming systems (zero grazing and semi-zero grazing with pastures), size of landholdings/herd and owner-ship/ management. However, they have one thing in common which is that they all are in dairy farming as a business.
This commercializing segment of farmers consists of Smallholders who invest in dairy as a core business and have been able to grow their dairy business to "the next level". These farmers are fully commercial however limited in their growth by lack of capital, land and the inability to grow and preserve fodder in sufficient quantities. Often the household has various sources of income from on-farm and off-farm activities/employment, and part of this is invested in the dairy enterprise. These farms have 5 up to 15 lactating cows and produce over a 100 litres of milk per day on landholdings ranging from 1-5 acres in the densely populated Mount Kenya milk sheds (zero- grazing) to 5-10 acres in other parts of Central Province (Kinangop, Nyandarua) and North Rift (semi-zero grazing). Often land is leased for fodder production [9, 29]. Medium and large-scale farmers who have "(re-) discovered" dairy farming as a profitable business.

Some are farm owner-manager. But many of these are well-off Kenyans with ample land and resources and a passion for farming, and usually in formal employment or on retirement. The level of mechanization is much higher as compared to the former segment of farmers, especially fodder production and preservation is fully mechanized. Farm sizes and herds may go up from 20 to 500 acres and 20-100 cows respectively. A good number of the MSFs are landowners with formal jobs outside agriculture, also referred to as "telephone farmers". Medium scale famers invest often quite heavily in dairy usually lack sufficient skills to make the dairy farm profitable [9]. Generally, farmers in Kenya are very focused in improving the quality of their herd, milk production and move towards efficient operations on their farms, amongst many other areas. This is mainly due to the revival of the dairy sector, high milk prices, increased business acumen and levels of education of owners and managers.

Characteristics of dairy production systems

Dairy farming in Kenya is concentrated in the high altitude agro-ecological zones of the central highlands and Rift Valley regions with a high and bimodal rainfall and relatively low temperatures between 15ºC and 24ºC. More than three-quarters of the households in the two regions engage in agriculture with 73% practicing integrated crop/dairy production. Slightly over half (54%) of smallholder faming households holding up to one acre of land keep cattle. In 2015, the Kenyan dairy cattle population was estimated at 4.3 million and produced over 3.43 billion litres of milk. Smallholder dairy farmers accounted for over 80% of the total national milk output [32].

In 2007, the Ministry of Livestock Development estimated that the national dairy cattle herd was made up of 50% cows, 10% heifers of over one year [3]. Dairy cattle are kept under intensive and semi-intensive production systems, with the distinction made between the two based on size, level of management and use of inputs. In places with higher population density, many keep their animals confined on farm and stall-feed them crop residues and planted fodder. Smallholders using more intensive systems for dairy production typically produce on a few acres only usually less than three with a herd size of one to five pure or crossbred cows or a mixture of both. Less intensive systems combine stall-feeding and some grazing [22].

Fodder interventions

As regards to improved production of fodder crops in medium and large-scale farms, the Kenya market-led dairy program (KMDP) had numerous interventions aimed at improving quality of feeds at farm level. Hay and maize (and to some extent Napier grass and fodder sorghum), are the main fodder products preserved by dairy farmers [9]. noted that both hay and maize production and handling (i.e. preservation, storage) had room for significant improvements and optimization, if management and mechanization are enhanced. As for grass and hay, large improvements were made in total kgs of dry matter harvested per acre, protein content and digestibility, after properly being fertilized and harvested at the correct time or stage [27, 28]. Together with pasture management this has been one of the successful innovations brought by KMDP/PUM. There is also scope for improved fodder seed varieties.

The Maize Train concept and baling of maize silage have shown that this is possible and goes with huge benefits for the dairy farmer and crop farmer [5, 10]. Baling maize silage is a new technology for the Kenyan forage market, introduced by Forage Innovation Team (FIT Ltd) with the support of KMDP. As compared to hay in the commercial forage market (over-priced and of low quality), baling of maize silage gives opportunities to provide quality forage, transportable over long distance, without losses of dry matter and nutritive value. The bales have a long shelf life if not opened or damaged can be stored for long (up to one year), this gives high flexibility in terms of availability and sales throughout the year, with likely the highest margins in the dry season [10]. The Service Provider Enterprise (SPE) is an innovative youth-led business model in which young men and women formed groups to offer commercial support services to entrepreneurial smallholders and medium-scale farmers in the vibrant Kenyan dairy value chain where silage making and fodder establishment were the main services they offered to dairy farmers [18]. *Rumen8* is a dairy ration calculation software. It was developed by Dr Martin Staines and Richard Morris in Australia [10]. It allows dairy advisors to manage forage based dairy cow diets to increase milk production and/or reduce feed costs. The use of the *Rumen8* software and the availability of good quality forages in abundance, has proven to be mutually reinforcing.

Effects of the interventions on dairy performance

A market study in North Rift (Nandi, Uasin Gishu, Elgeyo Marakwet -Kitale) carried out in 2018 showed that 5 years after KMDP started operations in North Rift, out of the 250 medium and large-scale dairy farms covered by the study, 175 farms were making silage with on average 21 acres of maize silage per farm in 2018 (total area under maize for silage was 3,625 acres). The acreage dedicated to maize silage had increased significantly over the last few years, and most farmers indicated that they planned to increase the acreage for forage maize considerably. The study confirms that the concept has been adopted widely and is now part of most commercial dairy farm practices in North Rift with a milk production of 100 litres or more per day [7, 10].

When diets are formulated to contain an equal amount of forage DM, neutral detergent fibre (NDF) concentrations of diets generally will be higher for diets containing grasses compared with legumes. Increasing dietary NDF concentration often has a negative impact on the amount of DM consumed by lactating dairy cows [1]. It is common for dairy producers to supplement forage with concentrates based on the average requirement of the herd, which is described as flat rate feeding by [12]. Where flat rate feeding is practiced, all cows are offered the same amount of concentrate DM irrespective of individual cow's potential milk production, BW, or stage of lactation. Several recent studies show that the protein efficiency (ratio of milk protein to feed protein) increases as dietary protein concentration decreases [14, 6]. Further [31], noted that decreasing dietary CP should result in lower N losses via urinary and milk urea. Therefore, it might be expected that the N-conversion efficiency from feed to milk would rise if protein concentrates are restricted or omitted and roughage quality remains good.

According to [20] and [13], the optimal dairy cattle feeding regime should consist of 75% energy, 24% protein and 1% mineral sources. Energy is necessary for body maintenance, milk production, growth, weight gain and reproduction. Protein is necessary to break down the roughage into usable nutrients. Younger plants, particularly legumes (pasture and fodder), have a rich protein and vitamin content. Examples of protein sources are bean straw, sweet potato vines,

Desmodium, Lucerne, fishmeal, sunflower and white clover as well as fodder trees such as Calliandra, leucaena, mulberry and Sesbania. The higher dietary starch in the corn grains treatment would likely cause an increase in insulin concentrations, and insulin seems to play either a direct or indirect role in milk protein synthesis [2].

Effects of the interventions on milk yield

Utilization of diets by dairy cows is largely influenced by the nutrient composition and physical characteristics of the forage in the ration. Grasses generally contain higher total NDF and potentially digestible NDF concentrations, which have a slower rate of digestion but greater extent of digestion than legumes affecting milk yield [27]. In general, lactating dairy cows fed grass-based diets have lower DMI and milk production compared with cows fed legume-based diets [32, 33]. The variation in maturity at ensiling during the grain filling period results in major changes in the content and composition of the carbohydrates (starch/NDF ratio) in maize silages, affecting silage DMI, milk yield and milk composition of dairy cows.

Increased protein content of pasture milk over total mixed ration (TMR) milk has been shown by [8] who reported a linear increase in milk protein content with increasing pasture content of the cows' diet. They attributed the increase in protein content to a modification of energy provided to the udder by an increase in propionic acid supplied to the rumen from grass diets [25]. A study by [23] showed that farms practicing fodder conservation had a higher milk yield and higher income per cow than control farms. Farms practicing fodder conservation obtained 3 litres more milk per lactating cow per day on average compared to the control group. A similar difference of 3 litres per lactating cow per day was observed when comparing farms practicing feed rationing in addition to fodder conservation, compared with those only doing fodder conservation.

An animal's feed intake, and how well that feed is digested, determine the feed's production performance. The nutritive value, or energy content, of an animal feed is determined predominately by its digestibility, which affects intake, or how much the animal will eat. Digestibility and intake, in turn, determine the feed's productive performance, such as to support milk synthesis or muscle growth [11]. The performance of animals maintained in resource-poor surroundings is usually poor due to seasonal fluctuations in the quality and supply of animal feeds. When accessible even in limited quantities, the fibrous feeds such as cereal crop residues and poor-quality mature grasses cannot maintain animals during much of the year [26, 15].

Use of SPE silage-making services was most frequent among farmers in Central and Eastern regions, where the majority (75%) of farmers used the services at least four times in 2016 [17, 18, 10]. SPEs were formed mainly to support farmers increase silage production and use. Silage making services include harvesting, chopping, compacting and tubing and, sometimes, provision of the materials required for ensiling. Maize silage was the most common silage made by all SPEs, with an estimated 9,415 tons made in 2016 (about 83% of the total silage made) [18, 10]. Scarcity and low quality of feed resources constitutes one of the major constraints to improved dairy productivity. Therefore, improving the efficiency of feed conversion to milk can have a significant impact on the productivity and profitability of dairy farms. This experiment aimed to determine the actual nutritional quality of dairy ration ingredients and fodder crops used in interventions adopted by dairy farms in Kenya.

Effects of the interventions on milk quality

Milk quality may be significantly affected by feeding strategies. Forage-concentrate proportions and the origin of roughages affect the concentration of value-giving n-3 fatty acids (FA) and conjugated linoleic acids in milk fat [16, 30]. Corn grain is typically substituted for forage in dairy cattle diets to increase the energy density of the ration providing glucose precursors for milk production and substrates for microbial protein production. Identifying alternative feedstuffs that provide energy and maintain milk component yields will decrease dependence on high-starch ingredients such as corn. Non-forage fibre sources (NFFS) have been researched as alternatives to starch for lactating dairy cattle [4]. Similar studies by [8] found that the use of a TMR feeding system can produce milk with higher fat contents. Feeding of TMR diets high in unsaturated fatty acids (UFA) has been linked with a reduction in milk fat content as UFA are toxic to many rumen bacteria, particularly those responsible for fibre degradation, resulting in reduced activity of acetyl CoA carboxylase enzyme and de novo synthesis [25].

Effects of the interventions on dairy economic performance

The Kenyan dairy sub-sector is threatened by the high cost of milk production which results to reduced profitability levels among different dairy enterprises [24]. Feed accounts for 50-70% of total cost in dairy farms and is the greatest contributor to low farm profitability [24]. Strategies to improve farm profitability is therefore focused on improving feed quality and utilization efficiency so as to reduce feed costs per unit of output. This has been partly achieved through the fodder interventions [24, 23]. Improving fodder conservation and utilisation efficiency through high quality forages and alternative feeding practices has the potential to increase farmers' income, in addition to yielding positive effects on the environment through the use of nitrogen. However, the high seasonality in feed availability is a key threat to milk production in Kenya [24].

Effects of the interventions on seasonal dairy production

Study by [23] noted that the use of service provider enterprises (SPE) fodder intervention and Ration formulation had no significant seasonality effect on airy production and therefore could have succeeded in maintaining a more stable availability of fodder over the seasons, which was not the case with the maize train intervention. Since the Maize train farms were in the potential maize belt zone, maize silage and maize stover were more available after the rainy season, which affects productivity of cows. [23] also noted that Monthly milk yield per cow was more seasonal in the Maize train farms than in the farms practicing ration formulation.

Conclusion

In conclusion, practicing fodder conservation interventions leads to improved dairy performance. The benefits from fodder conservation interventions increased when fodder conservation was combined with ration formulation interventions as observed in a study by [23]. Additionally, the profitability of farms practicing fodder interventions only was better compared to farms not using the interventions. Additionally, there is need for the development of a strong commercially driven "service infrastructure" for the dairy

value chain. In particular, directed towards supporting the establishment and management of best practice mechanised fodder production, and preservation.

Recommendation

Dairy farmers should adopt fodder conservation measures in combination with ration formulation in order to increase their milk yield and profitability. Dairy ration formulation programs should include follow up visits with advisory services for a longer duration to enable farm managers to better understand the concepts involved in formulation and fodder conservation. Focus on quality in the execution of all steps in the silage making process is the shortest route to reduce the nutritional losses in dairy feeds.

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