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The Effect of Quality and Quantity of Feed on Milk Yields of Dairy Cows: Review

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Abstract

This review was focused on the effect of quality and quantity of feed on milk yield of dairy cows. Feed resource availability in quality and quantity has adverse effect on milk production on dairy animal. As per the effect of feed resource on milk yield of dairy cows in order to improve the effects in its quality to increase milk yield production level. The quality of feed resources availability in tropics and sub-tropics have not been extensively characterize for the different farming system. Tropical feed resources are generally limited in the supply of required nutrient for the optimum functioning of rumen micro-organisms. Dairy cattle require nutrients for maintenance, growth, production and reproduction. Nutrients required for these function expressed interims of energy, protein, minerals (mainly calcium and phosphorus) and vitamins. Besides the potential availability of non- conventional feed resources as stock feeds have not been exhaustively explored. With this regard the review reported that the effect of feed resources on milk yield of dairy cows and to improve feed quality and quantity management in improvement goals. Most dairy farmers tend to give more attention to the overall milk yield in their dairy cows and pay less attention to the overall milk components of a their dairy herd. However, consumers and dairy product producing companies that buy milk from dairy farms are more interested in milk components than milk yield. Hence, milk of dairy farmers known to produce milk that has high percentage of components such as fat and protein tend to be more profitable in markets than milk with low percentage of these components. Milk quality problems of the overall dairy herd of a farm are more likely affected by nutrition which is in turn affects milk composition. Therefore, poor knowledge of the relationship between dairy cow nutrition and milk components results in production of low quality milk with low milk.

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Introduction

Back ground

Both smallholder and pastoral herds suffer inadequate feed supply and handling to support good quality milk production indicators of fat, protein, and solid contents (Njarui *et al.*, 2011). Feeding recommendations for dairy cows include an optimum ratio of forage to concentrates of 60 to 40% with variation between 55:45 and 65:35% being optimal in ammonia N levels, free amino acids, and acetate: propionate ratio (Kljak *et al.*, 2017). The levels of inclusion of concentrates influence milk yield, fat, and protein. Pandev and Voskuil, 2011 have recommended a daily dry matter (DM) intake of 3.6 to 4% of bodyweight for milking cows. They further suggest 0.2 to 0.3% of daily feeds to be proteins. The fibrous feeding material, important for ruminant nutrition, is needed inadequate amounts between 40 and 50% of the diet for crude fiber with 19–21% of ADF and 26–28% of NDF (Pandev and Voskuil, 2011). Feeding practices are likely to influence milk yield and composition in smallholder dairy cow. Small holder dairy cow herds are fed on on-farm grown fodder, crop residues, externally sourced forages, and commercial dairy meal.

Milk of dairy cows is composed of water, proteins, fats, lactose, minerals and other dissolved components (vitamins and white blood cells). It can be noted that about 87.7% of milk is water, in which all other constituents are distributed in various forms (Closa, 2004). However, the main focus of this study is on fat and protein content of milk. The percentage of each component varies from one breed to another, but generally milk is composed of 87.7 %; protein 3.3%; fats 3.4%; lactose 4.9%; mineral salts 0.7%. The main driving forces for manipulating milk composition in dairy cows are the same now as they were 25 years ago; aimed at improving the manufacturing and processing of milk and dairy products, changing the nutritional value of milk to conform to the dietary guidelines, and using milk as a delivery nutraceuticals with known benefits to human health (Haug *et al.*, 2007). Nutritional strategies that impact on milk components include adequate rumen degradable rumen protein and adequate feeding of forage neutral detergent fiber (NDF) in the diet especially for cows in early lactation. The impact of nutrition and nutritional changes in the ration can readily alter fat concentration and protein concentration. Fat concentration is most sensitive to dietary changes and can vary over a range of nearly 3.0 percentage units (Grainger and Goddard, 2007). Dietary manipulation in milk protein result in milk protein concentration approximately 0.60 percentage units (Jelen and Lutz, 1998). The concentration of lactose and minerals, which are other solids constituents of milk, do not respond predictably to adjustments in diet. There are also many non- nutritional factors that can affect milk composition such as genetics and environment, level of milk production, stage of lactation, diseases, season, cow comfort, facilities and age of the cow (Jenkins, 1998).

The effects of feeding practices on milk yield

Milk yield from the dairy cows under smallholder farmers is far below the expected genetic potential of the cows due to several factors, one of them being improper feeding practice, which deprive nutrients supply to the animals (Mtengeti *et al.*, 2008). Most of the feeds provided to dairy cows by the smallholder farmers are forage based with little or without concentrate supplementation. Maize bran is mostly used as a major supplementary feed to lactating cows without considering the nutrient requirements of the animals. This situation suggests that there is a need to put in place a proper feeding practice in order to improve performance of dairy cattle under smallholder farmers.

Quality of available feeds for smallholder dairy cattle production

Quality feeds are able to supply the most nutrients required to meet the animals' requirements for maintenance and production. Feed quality, which is influenced by its nutrient composition, determines the intake and availability of ingested nutrients for utilization by the dairy cattle because high quality feeds offer greater dry matter intake (DMI) and digestibility than low quality feeds. In most of the tropical areas where there is a distinguishable wet and dry seasons, a wide seasonal fluctuation in availability, chemical composition, digestibility and nature of digested products of feeds particularly forages is very common. The common feedstuffs used by smallholder dairy farmers for feeding animals are forages, crop residues and concentrates. The amount of feed consumed by the animal is very important as it affects the total nutrient intake and hence animal performance.

Forages and crop residues

Forages are bulky feeds cut and fed to animals particularly cattle kept under zero grazing system either as fresh green fodder or conserved as hay or silage. Common forages used to feed dairy cattle under smallholder farmers are natural pastures (NP), such as grasses and crop residues. The common crop residues are maize Stover, rice straws, bean hauls and sugarcane tops (Temi, 1991).

The crude protein (CP) content of P. maximum and P. purperium was observed to vary with season, ranging from 6.5 to 8.5% and 7.8 to 10.2% during dry and wet seasons, respectively (Mtengeti *et al.*, 2008). The CP content of *P. purpureum*, was found to be higher than that of *P. maximum*. However, the two grasses had CP levels lower than the required level of 12% DM for a dairy cow producing at least 10 litres of milk per day (McDonald *et al.*, 2010). Legumes, such as *V. pubescens* and leaf meals of multipurpose trees, such as *Leucaenaleucocephala* and *Gliricidiasepium* were reported to have CP ranging from 17-27% and 22-30% DM, respectively (Machibula, 2000 and Kakengi *et al.*, 2001).

The requirement of a dairy cow (12% DM) producing at least 10 litres of milk per day. According to McDonald *et al.*, (2010), the chemical composition of forages in East Africa particularly native grasses or introduced species in a particular environment normally tends to vary widely not only by species but also with maturity, soil and climate. When plants grow require more fibrous tissues to maintain their structure where by the main structural carbohydrates namely cellulose and hemicelluloses and lignin increases and the concentration of protein (CP) and total ash content decreases. Soil type affects mineral content of pasture as soil acidity has influence on the uptake of many trace elements by plants (McDonald *et al.*, 2010). Also the amount of rainfall affects mineral composition of pasture, for example, calcium accumulate more in plants during period of drought while phosphorus seems to be in higher concentrations during rainy than dry season. The low DM content may lead to low intake of protein and minerals contained in it and thus resulting into poor animal performance. In Kibaha, Pwani region, Nkenwa (2009) reported values of in vitro dry matter digestibility (IVDMD) and energy content of mixed forages, such as natural grasses and legumes to be 48.09% and 7.02 MJ ME/kg DM, respectively. These values were below those values reported for medium quality forages, which contains more than 55% IVDMD and 10 MJ ME/kgDM (Meissner *et al.*, 2000). Inadequacy of high quality forages under smallholder dairy farmers is one of the major constraints limiting dairy cattle production.

Mixing the grasses with legumes has been reported to result in higher intakes of energy, protein and weight gain (Lukuyu *et al.*, 2012). Legumes fix atmospheric nitrogen in the soil and thereafter the released nitrogen is utilized by the accompanying grass. However, smallholder dairy farmers have not been able to adopt the innovation of mixing grasses and legumes while feeding cows for a number of reasons, one of them being the difficulties associated with establishing and managing such stands particularly when legumes are planted with vigorous grasses such as *P. purpureum* and *Tripsacumlaxum*. On the other hand, mixing grasses and legumes for feeding stall fed cows where farmers depend on NP as the major feed sources for their dairy cattle is a challenge (Mtui, 2004).

Maize stover and rice straw have been reported to contain poor nutritional values (McDonald *et al.*, 2010). When dry period extends, farmers are forced to use other crop residues, such as wheat straw, bean straw, banana leaves, banana pseudo stems and sugar cane tops (Lukuyu *et al.*, 2012). Most of tropical forages and crop residues are low in nutritional quality due to high temperature, which leads into low digestibility and hence low energy values (Gillah *et al.*, 2013).

Concentrates

Concentrates are feeds rich in nutrients particularly energy, protein or both and provide far more nutrients than an equivalent weight of roughage. Therefore, they are fed in relatively small amounts together with the bulk feeds, which are forages to productive animals such as lactating or pregnant cows. They are usually low in crude fibre and high in total digestible nutrients. Concentrates are classified as energy concentrates when energy is the major nutrient contained in it and protein concentrates when protein is the major nutrient in it. Energy rich concentrate sources available to dairy cattle under smallholder farmers in the tropics are cereals or cereal by-products such as maize, hominy meal (HM), maize bran (MB), rice polishing (RP) or roots and tubers. Liquid feeds such as molasses, fats and oils are added to a ration primarily to increase its energy density. Energy rich concentrate sources also contains proteins, minerals and vitamins in small quantities (Lukuyu *et al.*, 2012).

Tahir *et al.*, (2002) reported a higher milk yield of 18.05 l/day in HM based diet compared to wheat bran (14.65 l/day) and rice bran (12.87 l/day) based diet when supplementing lactating cows. Maize bran (MB) is another by-product of maize processing industries used as a source of energy for feeding animals and is less expensive than HM. It consists of the bran coating removed in the early steps of processing maize usually with a mixture of the bran fraction and other by-products. Mulumpwa *et al.*, (2009) reported that high variability in cell wall content of MB results in variation in digestibility and energy content. On the other hand, Cardenas *et al.*, (2002) and Tahir *et al.*, (2002) reported that for cows with medium level of production, MB can be used fully to replace maize in their concentrate mixture without affecting milk quantity and quality.

However, during the dry season, MB has to be combined with protein sources like sunflower seedcake for increasing milk yield (Mlay *et al.*, 2005). MB has been reported to have an advantage of providing energy without causing negative digestive interactions with other ingredients. Various factors contribute to the variations in nutritional values across the areas. These include stage of harvest, processing methods, storage condition and method used to analyze the concentrate feeds. Lactating dairy cows supplemented with a MB-SSC concentrate mixture containing 31% SSC fed at a rate of 4 kg/d were reported to have higher milk yields of 8.1 l/d/cow compared to 6.6 l/d/cow for those supplemented with the same amounts of MB alone (Mlay *et al.,* 2005).

Performance of dairy cattle under different feeding practices

Feeding practices in dairy cattle production involves all the activities of securing feed and water supplies from sustainable sources and the amount of feed to be fed to dairy cows. Smallholder farmers in Turiani division keep crossbred dairy cattle under zero grazing system. They mainly practice either of the following feeding practices; Firstly, forage feeding depending mainly on NP and crop residues obtained from communal areas, fallow lands, road sides and river banks. Secondly, forage with MB as sole supplement during milking and thirdly, forage feeding with mixed concentrate (MDC) supplementation, chopped banana pseudo stem and leaves, potato peals, weeds and crop residues. Zero-grazing is an intensive milk production system in which herbage is cut in the field and carried to indoor animals. Feeding system has an influence on dairy cattle productivity due to differences in management.

Forage feeding

Smallholder dairy farmers depend on forages, mainly NP as main basal diet for their animals. Forage availability and their nutritional values in most tropical areas differ with seasons. During the wet season, forage materials are abundant with reasonable quality in terms of nutritive values for feeding dairy cattle. On the other hand, in the dry season the quantity and quality of forages are low. This fluctuation in feed availability causes seasonal variability in productivity of dairy cows under smallholder farmers in the tropics (Mtui, 2004). Several authors have reviewed seasonal variation in milk yield in relation to the availability of tropical forages. In Kenya by Kayongo (1991), revealed that there was abundant growth of pasture and fodders this was in excess of requirement during the rainy season. The ‘excess’ goes to waste since most farmers are not familiar or do not own facilities to conserve the excess herbage for dry season feeding.

On the other hand peri- urban it has been reported that nutritional value of forages decline with advancing dry season (Mlay *et al.,* 2001). This condition results into fluctuation in milk production from dairy cows due to low intake of essential nutrients, such as energy, protein, minerals and vitamins required for rumen microbial activities. High performance of lactating dairy cow depends on availability of good quality feeds, clean water and proper feeding practice. Extensive work has been done to assess performance of dairy cattle kept in different feeding systems under different feeding practices. Earlier findings from the dairy units of Nakuru in Kenya (Lanyasunya*et al.,* 2001) revealed that a feeding practice which depends only on forage or pasture without supplementation, milk production will depend on quality and quantity of the pasture. Nevertheless, it is difficult to realize the full genetic potential of a cow fed in that way. Lukuyu *et al.,* (2012) reported that a cow fed on *P. purperium* alone can produce 7 l/d whereas 9-12 l/d was obtained when fed on a *P. purperium*-legume mixture. The authors also reported that when Rhodes grass was fed alone the average milk yield ranged from 5-7 l/d, whereas 7-10 l/d was obtained when grass-legume mixture was used. Normally a feeding practice which leads to underfeeding of dairy cows results into low performance, which eventually climaxes into economic losses to smallholder farmers.

Concentrate supplementation

Concentrate supplementation in the tropics is a feeding practice employed by some smallholder farmers, mostly to their stall fed lactating cows. According to Gillah *et al.,* (2012), dairy farmers rarely feed concentrates at recommended levels and required quality. They supplement MB or MDC to relax the cows when milking at a rate of 2-3 kg/cow/d without considering the actual requirements based on the level of production of the animals (Richards and Godfrey, 2003). In addition, the types of concentrate mixture offered to dairy cows differ among farmers within the same location (Mtui, 2004). Most smallholder farmers prefer using MB singly as a concentrate to supplement their lactating cows while others use a mixture of more than one concentrate ingredients, such as MB and SSC; MB, SSC and RP and a mixture of MB, SSC, RP, mineral mixture and to a less extent leaf meals. However, the type of concentrate mixture and amount offered per cow per day differ from one household to another (Mtui, 2004).

Feeding of concentrates to lactating dairy cows have been reported to improve performance of the animals in terms of milk yield. Lanyasunya *et al.,* (2001) and Nkya*et al.,* (2008) observed that in the dairy units of Nakuru in Kenya and Morogoro in Tanzania, respectively where concentrate feeding practices were introduced, daily milk yield (litres/cow/d) improved from 7 to over 24 litres and 6.7 to 8.0, respectively. On the other hand, Scheinman *et al.,* (1992) reported an extra milk yield of 2-3 l/cow/d from supplemented dairy cows under zero grazing over the non-supplemented cows.

Basing on the fact that most of NP used by smallholder dairy farmers in the tropics arelow in their nutritive value, adequate concentrate supplementation practice is of great importance in order to improve performance of dairy cows to reach their genetic potential. This is in agreement with the observation made by Abate *et al.,* (1995) who observed that in sub-Saharan Africa the DMI of basal diets is usually inadequate because a wide range of selected genera and species of forages available for feeding dairy cows have low nutritive values, which also tend to vary with season. Therefore, to maintain higher levels of DMI in order to improve performance of dairy animals, various vegetative and concentrate supplementation is more essential. According to Gillah *et al.,* (2013) the level of milk yield in Eastern and Central Africa dairy units range from 5.7 to 17 litres/cow/d. A number of factors have been reported to contribute for the variation in milk production; among them feeding practices have greater influence on milk yield (Epaphras, 2004).

Crop residue feeding

Feeding of crop residues, mainly maize Stover and rice straws is another feeding practice done by smallholder dairy farmers especially during the dry season. Masama *et al.,* (2005) reported that farmers use a variety of crop residues to feed their animals because they are cheap and locally accessible. Utilization of alternative feed resources such as crop residues during period of forage scarcity is of importance under smallholder dairy production. However, the extent of use of crop residues to feed dairy cattle varies from place to place depending on the major crops grown, cost of collection and transportation, cost of storage and processing (Massawe, 1999 and Mpairwe, 2005). Because of their high fibrous content, low digestibility and low protein content, crop residues remain in the rumen for a long time leading to limited intake. Also they do not have enough crude protein to support adequate microbial activity in the rumen. The crude protein content of maize stover has been reported to range from 2.31 to 6.25% of dry matter (Mtui, 2004). Feeding practice, physical processing and chemical treatment are the ways used to improve utilization of crop residues. In Thailand, Wanapat *et al.,* (1998) reported that lactating dairy cows fed on a combination of urea-treated rice straw and whole sugar cane crop as roughage sources during the dry season improved the feeding values of these forages and increased dry matter intake (7.6 kg/d) and milk yield (4.47 l/d). The study by Masimbiti (2001) reported that lactating dairy cows fed on urea treated maize stover yielded higher milk (10.1 l/d) than those fed untreated maize stover (9.5 l/d) in Zimbabwe. Hence, dairy cattle fed on especially untreated crop residues need to be supplemented with readily available energy and degradable protein to supply nitrogen to the microbes in the rumen.

Feeding strategies during dry season

In the tropics there are times of plenty and times of scarcity of forages because both forages and fodder are rain-fed. This situation of seasonal availability stresses the importance of conserving the excess forage during rainy periods for use in dry season. Forages may be conserved either in form of hay, standing hay or silage. Hay is conserved green crops cut after attaining 50% flowering, a stage at which levels of protein and digestibility are at maximum (Lukuyu *et al.,* 2012). The cut crops are then dried to reduce the moisture content to a level low enough to inhibit action of plant and microbial enzymes and fungal growth. According to McDonald *et al.,* (2010) the moisture content of green crops depends on season and stage of growth and normally range from about 650 g/kg to 850 g/kg DM tending to fall as plant matures. In order for the hay bale to be stored satisfactorily, the moisture content should be reduced to 150 – 200 g/kg DM. Drying to reduce moisture can be either manually by sun drying, use of field machinery and barn drying. Manual drying and baling is more economical for smallholder dairy farmers. However, hay making in the tropics is not widely used because grasses are abundant in the rain season that interrupt drying process in the field, vigorous growth of grasses which leads to rapid decline in protein content and digestibility as a result it becomes very difficult to combine a good yield with satisfactory nutritive value (Lukuyu *et al.,* 2012).

Standing hay are forage stands left to dry on the field for use during period of scarcity. Forages conserved in that way are normally exposed to direct sunlight and rainfall for their whole time of conservation as a result deteriorate continuously leading to low quality (Lukuyu *et al.,* 2012). They are poorly digestible, low in protein, energy and minerals and therefore when fed alone do not meet the animal nutrient requirement for maintenance and production.

Silage making is another method of conserving forages whereby high moisture fodder are preserved through fermentation in the absence of air (McDonald *et al.,* 2010). Silage can be made from grasses, such as P. purpureum, fodder sorghum and green maize. The crops should contain an adequate level of fermentable sugars in the form of water soluble carbohydrates. Dry matter content in the fresh crop should be more than 200 g/kg DM and a physical structure that will allow it to compact readily in the silo. It requires a container or pit in which crop is ensiled after harvesting (Lukuyu *et al.,* 2012). Grass should be harvested when is about 1m high while maize and sorghum are harvested at dough stage where the protein content of the grass is about 10% and the grain for maize and sorghum is milky.

However, according to McDonald *et al.,* (2010), tropical grasses and legumes are difficult to ensile as they have a low water soluble carbohydrate content and are more highly buffered. Thus, for satisfactory ensilage; wilting of very wet crops, mixing of legumes with cereal crops and addition of molasses to provide a source of water soluble carbohydrates is important.

On the other hand, Lukuyu *et al.,* (2012) reported that in order to increase the level of crude protein and quality of the silage, poultry waste and legumes such as Lucerne and Desmodium may be mixed with the material to be ensiled but at a rate of not more than 5% and 25% respectively of the total material ensiled. This is because protein has a buffering effect that increases the amount of acid (Muhammad *et al.,* 2014), therefore if used in large amount tend to lower pH below the recommended value of 4.0 (McDonald *et al.,* 2010).

Nevertheless, the economies of scale in terms of materials and labour intensive make silage making to be low under smallholder farming systems. Mannetje (2000) reported that silage making in the tropics is low because of limited know how among farmers, lack of finance and labour intensive. Silage making is considered to be cumbersome. In a study by Lyimo (2010), in-bag grass silage quality within small scale farmers in Mvomero district revealed that smallholder dairy farmers could easily use strong plastic bags. The plastic bags having capacity from 5 kg fresh chopped green fodder grass could be easily used, a technology employed in Zimbabwe, Benin and Kenya highlands. This technique allows conservation of available forage in small quantities over a long period compared to the pit method. In Turiani division, however, only a small proportion of farmers are aware on silage making. Similarly in central Uganda, Muhammad *et al.,* (2014) reported only 10% of smallholder farmers knew about silage making as one of the methods of feed conservation. However, Kaiser *et al.,* (1993) reported that when lactating dairy cows were fed on silage containing 11 MJ ME/kg DM as the sole feed, the cows produced 1.28 l/kg silage DM.

Treatment of low quality roughages

In most tropical countries crop residues, mature hay and over grown P. purpureum which are used to feed animals especially during dry season, are of low quality. Because of their high fibre content and low digestibility which tend to limit both their intake and utilization, several methods have been developed to ameliorate their quality. The common methods used to improve the quality of forage are physical, chemical and biological treatments. Physical treatment of low quality forages such as chopping to about 5cm before feeding even though it does not improve digestibility, it increases its intake, reduce wastage and make it easy to be mixed with other feed components, such as legumes (Lukuyu *et al.,* 2012). Grinding and pelleting are physical treatment of forages which improve its intake but when forages are finely ground (1mm) and fed to animals, it has been reported to result into less sorting, higher intake, less gut fill, higher passage rate and consequently lower digestibility (3% legumes and 15% grasses) (Chenost and Kayouli, 2003).

The use of chemicals such as alkali and urea to treat low quality forages have been reported to increase their feed intake and digestibility (Mtamakaya, 2002). Alkaline improves the quality of low quality forages by increasing their digestibility through swelling the cellulose and hydrolysis of the hydrogen bonds between the lignin and hemicelluloses which makes it easier for the enzymes to work (Walker, 2013).

According to Kimambo *et al.,* (2002) when maize stem, leaf sheath, air bract and rice straw were treated with alkali particularly Sodium hydroxide (NaOH), they were observed to improve their dry matter digestibility by 64.6%, 33.9%, 63.5% and 59% respectively. Mlay *et al.,* (2001) revealed an improvement in microbial protein synthesis and NDF digestibility when hay was treated with Sodium carbonate, an alkali commonly known as Magadi. Contrary to the previous observation

Nkenwa (2001) and Mtamakaya (2002) in their studies using wood ash for treating rice straws and maize stover observed an increase in rumen dry matter and organic matter digestibility and a decrease in NDF content of rice straw. This was due to weakening of the bonds between the hemicelluloses, cellulose and lignin by the alkali which makes them to be susceptible to the action of microbes in the rumen.

Urea treatment of crop residues is done by sprinkling the chopped materials with urea solution mixed at a rate of 4 kg fertilizer grade urea in 100 litres of water. The mixing of the chopped material with urea-water solution can be done in a pit or on a plastic sheet on the ground before packing in a pit. This improves the nutritive value by increasing the digestibility, palatability and crude protein content (Lukuyu *et al.*, 2012). The pit remains closed for one month during which urea is being converted to ammonia which then breaks down some of the bonds in the fibrous material making them accessible to microbial enzymes. Urea treatment was reported to be the most practical significant in tropical countries like Tanzania. It acts both as alkali and a source of nitrogen to materials which are low in crude protein (Kimambo *et al.*, 2002).

Urea treated rice straws were observed to increase their CP content by 1%, that is from 6% to 7% and a decreased in NDF from 60.96 to 56.97% (Mtamakaya, 2002). Masimbiti (2001) in a study on utilization of urea treated maize stover in rations for dairy cows in Zimbabwe reported that lactating dairy cows fed on treated maize stover produced extra 0.6 litres of milk than those fed on untreated maize stover, that is 10.1 l/cow/d versus 9.5 l/cow/d. On the other hand, feeding urea-molasses block together with crop residues is another technique which provides both nitrogen and energy to the microorganisms in the rumen and therefore improves the digestion of the crop residues (Walker, 2013). Therefore, this microbial conversion appears to be a practical and promising alternative for increasing the nutritional value of poor quality forages by transforming them into animal feed and producing a value-added product. Such observations and others indicate that if crop residues and poor quality hay are efficiently utilized there is a potential to improve milk production by crossbred lactating cows under smallholder farmers in the tropics.

Supplementation

Low quality forages when supplemented with good quality grasses, legumes or concentrate feeds significantly improve feed intake and animal performance. During the dry season where forages are scarce and of low quality, supplementation of the basal diet with good quality forage or concentrates helps to reduce the problem of low palatability and intake. Different studies have reported high milk production when poor quality forages are fed with different levels of concentrates and/or supplemented with multipurpose trees. A study by Nkya *et al.,* (2002) revealed that supplementation of forages with concentrates at a rate of 0.8 kg per litre of milk produced was linked with an increase in milk yield of 1.26 l/cow/d and a body weight changes of 0.25 kg. The same results were reported by Fike *et al.,* (2003) who observed an increase in milk yield by 11.3% on lactating cows supplemented with 0.8 kg of concentrate per litre of milk produced compared to un-supplemented group. Supplementation of basal diets with good quality forage or concentrates in the tropics particularly during dry season improve intakes of low quality forage as well as milk yield of dairy cows. In a study with lactating Mpwapwa breed cows receiving 6.8 kg/cow/d of hay and supplemented with 4 kg DM/cow/d concentrate, Bwire and Wiktorsson (2003) observed higher milk production of 6.2 l/cow/d compared to 5.0 l/cow/d produced by those supplemented with 2 kg DM/cow/d of concentrate. Other results by Bwire (2002) on a study with dual – purpose lactating cows reported a higher milk yield of 5.3 l/cow/d from cows fed on grass and supplemented with 3.1 kg DM/cow/d compared to 4.8 l/cow/d obtained from cows fed on a combination of grasses without supplementation.

Supplementation of lactating dairy cows with 4 kg/cow/d of a concentrate (68% MB, 31% SSC and 1% cattle mix) in peri-urban and urban areas of Morogoro was reported to improve live body weight by 0.63 kg/d, body condition score and milk yield by 1.5 l/cow/d in a 12 weeks period (Mlay *et al.,* 2005). Urassa (2012) in a study on supplementation strategy for improving milk production of crossbred dairy cows under smallholder farmers in Kibaha district observed that lactating cows receiving 5 kg/cow/d of hay made of P. maximum on top of basal diet and supplemented with a home made concentrate at a rate of 5 kg/cow/d produced 4.66 l/cow/d more than the un-supplemented cows. Other finding by Nkya and Swai (1999) revealed that supplementation with urea molasses mineral blocks to lactating dairy cows supplied with grass hay ad libitum and MB at a rate of 6 kg/cow/d for a period of 49 days during the dry season increased milk yield from 6.7 to 11.2 litres of milk per cow per day and DMI from 10.1 to 12.0 kg per day. However, as the population of rumen microorganisms depends on the composition of feedstuffs consumed, feeding of high-energy feedstuffs should consider the required roughage: concentrate ratio as excess of concentrate may have a negative associative effect on the degree of utilization of roughage. The end products of fermentation of high energy feedstuffs in the rumen are propionate and lactate which are both strong acids relative to acetate. Acetate is obtained after digestion of forages by cellulolytic bacteria. As the rate and extent of digestion are high for high-energy feedstuffs the resultant pH of the rumen is reduced. Low pH (< 6) has a negative effect on the microorganisms responsible for digestion of roughages. Therefore, high rate of incorporation of high energy none fibrous carbohydrate feedstuffs decreases the utilization of roughages.

Supplementation with tree legumes has been reported to gain importance in improving performance of dairy cattle in most developing countries. Common tree legumes used in the tropics are *Leucaenaleucocephala, Gliricidiasepium, Moringaoleifera* and *Calliandra* (Temi, 1999).Tree legumes are good source of protein. In the tropics they are of potential especially during the dry period as they have deep root systems that can withstand drought and hence serve as main source of forage during the dry season (Temi, 1999). Kakengi *et al.,* (1999) reported that 2.6 kg DM of leucaena leaf meal (LLM) can substitute 1.8 kg DM of cotton seedcake without affecting cattle performance. The author observed that lactating dairy cows supplemented with LLM based concentrate showed more weight gain and high milk yield compared to those supplemented with cotton seed cake based concentrate at the same rate of 1.8 kg DM/cow/d.

According to McDonald *et al.,* (2010), the crude protein (CP) content of tree legumes range from 200 to 300 g/kg DM. Due to their high CP and mineral contents, tree legumes can be suitable alternative to concentrates in forage based diets. They can be easily established and maintained under farmers' condition. They are relatively cheaper compared to agro-industrial by-products used as source of protein for ruminant animals. However, tree legumes are high in neutral detergent fibre (NDF) ranging from 500 to 600 g/kg DM. Together with tannins, both reduce palatability of tree legumes and hence it's nutritional value making them as a food reserve to be consumed when grass herbage is limited, particularly during the dry season. The form in which the tree legumes are fed may influence how tannins affect feed intake (Reed, 1995). Drying before feeding reduces solubility of tannins and, hence, reduces their ability to complex protein as they become more polymerized resulting in a lower number of free hydroxyls available for binding the proteins. Sarwatt *et al.,* (2004) on a study with crossbred lactating cows fed on elephant grass (*P. purpureum*) based diet and supplemented with a concentrate in which cotton seedcake was substituted with *Moringa oleifera*, observed an increase in milk yield from 7.8 to 9.2 l/cow/d. On the other hand, Urassa (2012) observed an extra average milk gain of 5.39 l/cow/d from lactating cows supplemented with 4.7 kg DM/cow/d of a concentrate in which LLM substituted 15.9% of sunflower seedcake and 1.87 kg DM of *Chlorisguyana* hay compared to milk gain of 0.73 l/cow/d obtained from unsupplemented group.

Supplementation of essential minerals particularly calcium and phosphorus has positive impact on milk yield of lactating cows. Gimbi *et al.,* (2006) observed a difference of 2.5 litres (10.13 l/cow/d versus 7.63 l/cow/d) in milk yield between lactating cows supplemented with concentrate and the unsupplemented group due to additional phosphorus in the diet. Therefore, good feeding strategy especially during the dry season may be a useful tool for improving milk yield from dairy cows.

Nutrients requirement of lactating dairy cows

The aim of feeding dairy cows is to maximize milk yield by meeting the cow's nutrient requirements. The nutrient requirements largely depend on the amount of milk produced, which in turn depends on the stage of lactation, that is the period from calving to dry period, when milk production stops (Nelson and Knowlton, 2003; Pandey and Voskuil, 2011 and Heinrichs, 2014). All the nutrients required by the cow for milk production (except water) are in the dry material of the feed. High dry matter intake (DMI) results in high nutrient intake and high milk yield (Wheeler, 2011).

The amount of energy, protein and mineral required by lactating cows depends on maintenance, milk produced, growth and pregnancy (Lukuyu *et al.,* 2012). The nutrients required for maintenance is largely affected by the cow's weight, environmental temperature and activity. Deficiency of any nutrient may reduce microbial protein synthesis in the rumen which in turn affects amino acid passage to the small intestine and hence in milk production by dairy cow. Under zero grazing system where the forages are opportunistically obtained from communal areas, fallow lands, road sides and river banks, the animals are in most cases underfed especially in the dry season. Feeding of lactating cows should aim to provide nutrients for maximum milk yield, fast growing foetus and deposition of an energy reserve and regeneration of the mammary gland (Lukuyu *et al.*, 2012). Furthermore, according to MAFF (1984), metabolizable energy (ME) and crude protein (CP) requirement for milk production by dairy cows depends on milk composition. For the milk with 3.0% fat and 2.6% protein the values are 4.5 MJ ME/l and 0.081 kg protein/kg of milk, respectively. The ME and CP requirements of a dairy cow weighing 400 kg live weight and producing at least 20 litres of milk per day as indicated in Table 4 were calculated basing on these values.

Minerals are nutrients required to be supplied in the diet all the time in order for the animal body to function properly, that is, remain healthy, reproduce and produce milk (Lukuyu *et al.*, 2012). Some minerals are required in large quantities (macro-minerals such as Calcium and Phosphorus) while others are required in small quantities (microminerals such as Iodine and Iron).

Feeding management

Any situation that causes cows to eat abnormally or limits feed intake may affect milk components. Examples include: overcrowding at feed bunks, housing heifers with older cows in facilities at or near full capacity (Mentink and Cook, 2006). Feeding rations that encourage sorting and feeding infrequently in a conventional system (non-TMR) and also failing to push feed up or feed total mixed ration (TMR) enough change milk components. Feeding protein feeds before energy feeds and feeding grain before forage in non-TMR systems, all such feeding management practices change the dairy cow's milk components. These conditions can create slug feeding (one or two meals per day versus 10 to 15) or allow cows to eat high grain meals part of the time and high forage meals the remainder of the day. Ensure that fresh feed is available 20 hours each day, spoiled feed must be removed from the bunks, and shade or cooling must be provided during hot weather to help maintain normal intake and normal meal patterns. Finally, make ration changes gradually to allow rumen microorganisms time to adapt. Any reduction in the rumen microbial protein production from nutrition or feeding management imbalances will reduce milk protein by less of microbial protein for the cow to digest and depress fat by limiting volatile fatty acid production in the rumen (Emery, 1978).

Maximizing feed intake

The importance of maximizing feed intake is related to minimizing negative energy balance during early lactation (Dixon and Ernst, 2001). As dairy cows move into positive energy balance, body weight is regained, loss of body condition is minimized, and cows produce milk of normal fat and protein composition (Bequette *et al.*, 1998). Increased feed intake can improve milk protein by 0.2 to 0.3 percentage units. This increased milk protein percentage may be due to overall increases in balanced energy intake as total feed intake increases. High producing dairy cows should eat 3.6 to 4.0 percent of their body weight daily as dry matter. If a dairy herd is consuming less dry matter than 3.6 to 4.0 percent of body weight, production of milk fat and protein components may be limited. Hence, increased feeding frequency increases milk fat and protein component, especially with low fiber, high grain diets (Peticlerc *et al.*, 2000). The greatest response is seen in diets with less than 45 percent forage and when grain is fed separately, as in parlor feeding (Ouweltjes *et al.*, 2007). When diets are fed as total mixed rations, feeding frequency is not as important as long as feed remains palatable and is fed at least once daily.

Nutritional factors and feeding practices

All the factors affecting milk composition, nutrition and feeding management are most likely to cause problems (Jenkins, 1998). Milk fat depression can be alleviated within seven to 21 days by changing the diet of the cow. Milk protein changes may take 3 to 6 weeks or longer if the problem has been going on for a long period (Grainger and Goddard, 2007). Nutrition or ration-formulation changes are strongly correlated to milk fat than milk protein. Nutrition and feeding management are considered the best solutions to a milk fat or protein problem other than genetics (Bequette *et al.*, 1998).

Source of milk components digestion of fiber in the rumen produces the volatile fatty acids (VFAs) acetate and butyrate. Butyrate provides energy for the rumen wall, and much of it is converted to beta-hydroxy butyrate in the rumen wall tissue. About half of the fat in milk is synthesized in the udder from acetate and beta hydroxyl-butyrate (Dixon *et al.*, 2001). The other half of the milk fat is transported from the pool of fatty acids circulating in the blood. These can originate from body fat mobilization, absorption from diet, or from fat metabolized in the liver. Rumen microbes convert dietary protein into microbial protein, which is a primary source of essential amino acids for the cow. These amino acids are absorbed by the mammary gland and used to synthesize milk proteins.

Energy effects

In general, as energy intake or ration density increase and fiber decreases, milk fat content will be reduced, while protein content is increased (Jenkins, 1998). In contrast, as ration fiber levels increase and energy is reduced, milk protein is depressed and milk fat is increased. Lack of energy intake or lower energy digestibility may reduce milk protein by 0.1 to 0.4%.This reduction may result from underfeeding concentrates, low forage intake, poor quality forage, and failure to balance the ration for protein and minerals, or inadequately ground or prepared grains. Shifting rumen fermentation so that more propionic acid is produced is apt to increase milk protein and decrease fat content (Bauman and Griinari, 2003). However, excessive energy intake, such as overfeeding concentrates, may reduce milk fat content and increase milk protein. Normal protein levels can be expected when energy needs are being met for most of the cows (Bequette *et al.*, 1998). Often this is impossible to achieve with high producing animals.

Fiber effects

According to DePeters and Cant (1992), both fiber level and particle size contribute to the effectiveness of a fiber source for stimulating rumination (cud chewing) and salivation and maintain optimal milk protein and fat composition. Minimum acid detergent fiber (ADF) levels required in the of ration dry matter are 19 to 21 percent. Neutral detergent fiber (NDF) should not fall below 26 to 28 percent. Below these levels, cows risk a low milk fat test, acidosis, lameness, chronic feed intake fluctuations, and poor body condition (especially in early lactation). In order to assure adequate particle length, forage should not be chopped to less than 8 centimeters. Chopping finer than this may dramatically decrease fat percent and increase milk protein by 0.2 to 0.3 percentage units. However, while this practice might seem advantageous, but when over feeding non-fiber carbohydrates (starchy concentrates), even though milk protein and fat content increases, the cow and her rumen may become unhealthy (Bruckermaier *et al.*, 2004). Feeding inadequate fiber is not recommended for increasing milk protein content (Mansbridge and Blake, 1997). Preferably, 75 percent of the neutral detergent in a diet should come from long or coarsely–chopped forage to fully satisfy the cow's fiber requirement. Rations too high in fiber (too low in energy) limit milk protein production because not enough energy is consumed. Generally, 40 to 50 percent forage dry matter in a ration is the minimum amount necessary to avoid low milk fat test. When feeding 65 percent or more forage, it must be of high quality to avoid energy deficiencies which also lower milk protein (Emery, 1978).

Protein effects

Protein tends to be overfed in rations either deliberately through ration formulation or due to inadequate monitoring of feed management practices. However, a deficiency of crude protein in the ration may depress protein in milk. Marginal deficiency could result in reduction of 0.0 to 0.2 %, while more severe restriction of diet crude protein would have greater impact (Neitz and Robertson, 1991). Feeding excessive dietary protein does not increase milk protein content, as most of the excess protein is excreted. Dietary protein has little effect on milk fat levels within normal ranges. Dietary protein type also could affect milk protein levels (Casper and Schingoethe, 1989). Use of non-protein nitrogen (NPN) compounds, like urea, as protein substitute will reduce milk protein content by 0.1 to 0.3% if the NPN is the main provider of crude protein equivalent. Rations higher than recommended in soluble protein may lower milk protein by 0.1 to 0.2 %. Non-protein nitrogen levels in milk will be increased by excessive protein or NPN intake, heavy feeding of ensiled forages, ensiled grains, immature pasture and lack of rumen undegradable protein in the diet. The rations for crude protein, rumen undegradable protein, and soluble protein must be balanced for better milk protein content. For high producing cows, balancing for amino acid also may be essential (Bequette *et al.*, 1998).

Protein nutrition is challenging because there are various nitrogen fractions, especially with ensiled feeds that add complexity when formulating rations and balancing them with carbohydrates. Excess protein fed results in increased nitrogen excretion (Jenkins *et al.*, 1998). However, it is also an animal concern as excess nitrogen feeding reduces nitrogen efficiency and thereby impacts on milk components.

Concentrate intake

Proper feeding concentrates primarily involves maintaining proper forage to concentrate ratios and non-fiber carbohydrate (NFC) levels (Cant *et al.*, 1991). Non-fiber carbohydrates include starch, sugars, and pectin. According to Gabriella et al (2005), non-fiber carbohydrates should range between 20 to 45%. A level of 40 to 45% is typical of diets with forage to concentrate ratios of 40 to 60 or less forage. Diets with large amounts of high quality forage and minimal grain may be deficient in non-fiber carbohydrate. Feeding proper non-fiber carbohydrate levels can improve both milk fat and protein content. However, overfeeding concentrates result to milk fat depression of one or more percentage units and often increases milk protein by 0.2 to 0.3% units (Berner, 1993). An increase in the intake of concentrates causes a decrease in fiber digestion and acetic acid production. This creates an increase of propionic acid production. Propionic acid production encourages a fattening metabolism that is in opposition to milk fat. Addition of buffers to some rations may help to prevent acidosis (Nyman *et al.,* 2009); this will not change milk protein, but will increase milk fat content. Animals that eat a substantial amount of concentrates or a low ratio or dietary forage to concentrate may develop acidosis even when buffers are added to the ration. The non-fiber carbohydrate (NFC) portion of the diet is highly digestible and can influence both fat and protein content in milk (Gabriella *et al.,* 2005). Excessive amounts of NFC can depress fiber digestibility, which reduces the production of acetate and leads to low milk fat (Emery, 1978). At the same time, greater propionate production allows higher milk protein levels of 0.2 to 0.3 percent. Generally non-fiber carbohydrate of 32 to 38% of ration dry matter is recommended to optimize production of milk fat and protein.

Grain processing effects

According to Kononoff (2006), grain intake should be limited to a maximum of 10 to 15 kg per cow daily. Manure which contains undigested corn or with pH less than 6.0 indicates that too much grain, or non-fiber carbohydrates, is being improperly (Vasupen *et al.,* 2006). Grain processing also influences milk composition. Feeding flaked corn increases milk protein content. Expect oats decreases milk protein by 0.2 percent compared to barley. Processed grain by cracking, rolling, grinding, or possibly steam-flaking enhances rumen starch digestion, which improves milk protein percentage. Pelleting also has similar effect. However, processed grain causes acidosis more easily than whole or very coarse-textured grains. Generally, rolled or ground barely or flaked corn causes a rapid and severe decrease in milk fat when overfed (Bauman and Griinari, 2003). Fibrous byproducts, such as soybean hulls, can replace a portion of starchy grains and reduce the severity of milk fat depression.

Forage level and physical form

Balance rations for lactating cows to contain at least 40 to 45 percent of ration dry matter from forage. This may be changed by the level of corn silage in the ration and the level of high fiber by-product feeds in the ration. Low forage intake can cause a major reduction in the fat content of milk due to low fiber levels (Mentin and Cook, 2006). Several potential reasons for low forage intake are inadequate forage feeding, poor quality forage, and low neutral detergent fiber (NDF) content in forage that was cut at a very immature stage or late in the fall stage(Bauman and Griinari, 2003). Target a forage NDF intake of 0.9% of body weight daily. Although low forage diets increase milk protein production, this strategy is not recommended. The low forage levels contribute to acidosis and laminitis; they do not promote good health for the rumen or the cow in a long run. Protein and fat content also can be changed due to the physical form of forage being fed. Much of this is related to ration sorting and failure to provide a consistent diet throughout the day. Coarsely chopped silage and dry hay are the most common causes of sorting. At the extreme, very finely ground diets negatively affect rumen metabolism and depress fat and protein production. Monitoring ration particle size to ensure that adequate effective fiber must be provided and Total Mixed Rations (TMRs) must be mixed properly and distributed evenly to all cows (Dixon and Ernst, 2001).

Added fat or oil and extremely high milk fat

Fat is generally toxic to rumen microbes and may reduce fiber digestibility when fat from natural resources exceeds 5% of ration dry matter. If rumen inert or by-pass fat is used, total fat content may safely reach 6 to 7%. At low levels of dietary fat, milk fat content could increase slightly or show no change at all (Gabriella *et al.,* 2005). Milk fat is reduced at higher levels, especially with polyunsaturated oils. If fat or oil is rancid, milk fat content decreases even at low levels of consumption. Milk protein content may be decreased by 0.1 to 0.3% in high fat diets (Gabriella *et al.,* 2005). This may occur due to reduced blood glucose levels. High milk fat content often occurs in herds that are off feed and may have ketosis problems. Percent fat may be reduced for sick animals, but total fat may be higher for the herd. This may occur in herds fed large amounts of good quality forage combined with moderate concentrate levels. Producing an abnormally high level of fat is not economically feasible, because it usually indicates that total milk production is low (Bailey *et al.*, 2005).

From the review, it can be concluded that productivity of dairy cattle under smallholder farmers in the tropics is still low, being constrained by a number of factors, the major one presumed to be poor feeding practices. Smallholder dairy farmers depend mainly on forages particularly natural pastures (NP) to feed their animals. However, most of tropical forages are low in nutritive values and when fed alone do not meet the nutrients requirement of the cows for both maintenance and production. Furthermore, in the tropics the quantity and quality of forages depend on rainfall, causing fluctuation in milk production. The use of different feeding strategies, such as forage conservation, treatment of low quality forages and use of supplements have been observed to improve productivity from dairy cattle. Poor feeding practices to lactating cows, such as sole feeding of NP, use of single concentrate ingredient, use of imbalanced concentrate and inadequate amounts of supplemented concentrate and forages offered are the major constraints to production as reflected by low milk yield. Therefore, a thorough assessment of existing feeding practices and performance of dairy cattle could assist in the formulation of appropriate feeding practice for improving dairy cattle productivity. It is also that the nutrition affect the quality of milk. Although nutrition is thought to affect quantity of milk yield produced, this study revealed that nutrition also has effects on milk components. Any nutritional changes in a the overall animal diet at any time should be properly rehearsed and evaluated for their effects on milk components and milk yield of dairy cows in both a short run and long run in dairy production.

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