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Physicochemical Quality of Milk from Dairy Cows Supplemented with Liquid Brewer's Yeast in Smallholder Dairy Farms

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Abstract

A study was conducted to evaluate physicochemical quality of raw milk from dairy cows supplemented with liquid brewer's yeast (LBY) in smallholder dairy farms. The milk was delivered from different routes to Githunguri Dairy Farmers' Cooperative Society in Kiambu County, Githunguri Sub-county, Kenya. The main objective was to ascertain suitability for use of LBY as alternative feed source for dairy cows without compromising on milk quality. Thirty farms (sampling units) were randomly selected from three milk delivery routes (sampling frame). A longitudinal survey was conducted where farms were nested within routes and equal number of farms selected per route based on supplementation of lactating cows with either LBY or commercial dairy meal (CDM). A repeated measure analysis was performed using the Linear Mixed Models methodology by PROC MIXED of SAS for milk quality and questionnaire data was summarized using descriptive statistics. Milk samples were analysed for physicochemical parameters such as butter fat (BF), protein, lactose, total ash, solid not fat (SNF), density and milk freezing point (MFP). The results indicated significantly ($p<0.05$) higher milk protein levels and lower freezing point for milk from LBY supplemented cows (3.07±0.03% and -0.532±0.005°C) compared to those supplemented with CDM (2.99±0.03% and -0.516±0.005°C). This was an indication of positive effect of LBY supplementation on the two parameters. The other physicochemical parameters were not significantly affected ($p>0.05$) by the type of supplementation regime, although higher levels were observed on LBY supplemented diets than CDM diets. The study indicates that LBY can be used as feed supplement for dairy cows without compromising on physicochemical quality of milk. In view of this, the research recommends use of LBY as a cost effective alternative protein source for dairy cows.

Keywords

Feed Supplement, Liquid Brewer's Yeast, Physicochemical Milk Quality, Smallholder Dairy Farms

1. Introduction

Kenya has experienced spectacular growth in dairy sub-sector both in terms of the number of dairy cattle and milk production since its liberalization in 1992 [1]. Dairy sub-sector accounts for about 4% of National Gross Domestic Product (GDP). In addition, it has a herd of over 3.5 million heads of pure bred dairy cattle and their crosses, 9.3 million indigenous cattle, 1 million camels and 13.9 dairy goats [2, 3] with annual production estimated at 5 billion litres of milk [4]; making it the most developed in Sub-Saharan Africa. Milk production in Kenya is dominated by smallholder dairy farmers estimated at over 1.8 million and own 3.3 million cattle out of the national estimate of 3.5 improved dairy herd distributed all over the Country. The smallholder dairy farmers contribute more than 80% of the total milk produced in the Country [1]. The sub-sector provides employment opportunities to more than 2 million people both in the formal and informal sectors, starting at the farm level to processing and marketing sectors, thereby contributing directly to poverty reduction and improved household income [5]. The two main milk marketing channels in Kenya are the formal sector that comprise of government licensed cooperative societies and processors or informal (unlicensed) channels that sell directly to consumers, milk bars or traders [6]. Kenya is largely considered to be self-sufficient in milk and dairy products. It is the only Country in Africa apart from South Africa, that is able to produce enough milk for domestic consumption and export save for occasional seasonal fluctuations during dry periods [7]. According to Ndungu *et al.* [8], increase in human population, urbanization, increased disposable income, greater diversity to meet nutritional needs and increased opportunities for domestic and external trade are expected to increase demand for milk and dairy products by 25% by the year 2025. This notwithstanding, food insecurity, low income and poverty are still major challenges among smallholder dairy farmers. This is generally due to inadequate and low quality feeds and high costs of inputs. The high cost of commercial dairy meal (CDM) has led to low levels of supplementation among most of smallholder dairy farmers, leading to low milk production.

In order to improve productivity in smallholder dairy farms, there is need to feed inexpensive and nutrient dense feeds to dairy cattle. However, supplementation with the available conventional protein sources such as cotton seed cake, soya bean meal, fish meal and sunflower seed cake is hampered by the high costs. Therefore, use of alternative high protein feed supplement such as liquid brewer's yeast (LBY) that is four times cheaper in Kenya than conventional protein sources is inevitable.

By-products from brewing process includes wet and dry brewer's grain, brewer's condensed soluble, liquid and dry brewer's yeast which pose serious disposal challenges to the industry [9]. The uses of sewer line and landfills as method of brewers' by-products waste disposal are expensive and unsustainable [9]. In order to reduce waste disposal costs, brewing industries sell these by-products as feedstuff for both ruminants and non-ruminant nutrition [10]. Brewer's yeast is an excellent source of protein of high biological value, greater quantity of amino acids such as lysine, leucine, isoleucine, valine, tryptophan, threonine and phenylalanine, with slight deficiency of sulfur amino acids [11]. Dried brewer's yeast has dry matter (93.6%), ash (7.0%), crude protein (48.9%), ether extract (2.4%), organic matter digestibility (89.7%) phosphorus 13.1 (g/kg DM), calcium 2.9 (g/kg DM) metabolizable energy 13.4 (MJ/kg DM) [12] and water soluble vitamins [9].

Calves can be given up to 200 g of dried brewer's yeast per day. Dairy cows may be fed 2.2 kg of dried brewer's yeast daily, which will provide sufficient protein for 30 litres of milk but enough energy for only 10 litres of milk. Hence, LBY should be fed together with an energy-rich low protein feed. If the use of LBY is proven to be a viable option, then introduction of such inexpensive protein source can play a significant role in enhancing dairy development in the Country as it can be used by resource poor smallholder dairy farmers.

In order to remain relevant in the very competitive milk processing and marketing in Kenya, farmers must produce good quality raw milk. Quality of raw milk can be influenced by a number of factors such as chemical composition, physical properties, microbiological and cytological quality, sensory properties, technological suitability and nutritive value [13]. Achievability of quality raw milk with all the desirable physicochemical properties for processing is normally very challenging. This is due to factors such as genetic characteristics of the cow, feed composition and milk handling practices among other factors as has been demonstrated in studies by Kitchen [14] and Mwangi *et al.* [15]. Nonetheless, nutrition plays a major role in milk production and its quality. This study was thus carried out to evaluate milk quality from cows supplemented using LBY.

2. Materials and Method

2.1. Study Site

The study was conducted at purposively selected farms in Githunguri Sub-county within Kiambu County, Central Kenya. The area is located at about 1600 m above sea level and lies between latitude 1° 05′ and 1° 06′ South of the equator and longitude 36° 53′ and 36° 55′. The soils are deep, well drained dark reddish to brown, friable clay, with a bimodal rainfall regime that starts in mid-March with a peak in April-May while the second rains begins in mid to end of October with annual average of about 1065 mm. The mean maximum monthly temperature in the region vary from 22.4°C to 27.6°C whereas the mean minimum temperature ranging from 11.3°C to 14.9°C.

2.2. Selection of Farms

Farms were systematically selected based on availability of lactating Holstein Friesian dairy cows (the animals were multiparous), feeding regime, accessibility of the farms for ease of supervision of feeding trends and willingness of the farmers to participate. The feeding system practiced in the area was cut-and-carry stall feeding system where Napier grass (*Pennisetum purpureum*) and crop residues are cut and fed to cows in stalls, commonly known as zero grazing. The animals were fed with Napier grass and crop residues ad libitum to meet both maintenance and production requirements. Lactating cows were supplemented twice at the time of milking with either CDM (at the rate of 2 kg per milking) or LBY (at the rate of 2 L per milking). The cows were milked twice daily at 4.30 am and 2.30 pm during the experimental period.

2.3. Sample Collection and Preparation

Bulk milk samples were collected from the 30 farms weekly during morning milking for a period of 4 weeks. This gave rise to a total of 120 samples for analyses. Sample collection was conducted as per AOAC 925.20 procedures [16]. The samples were transported in ice cooled boxes for analyses at the Guildford Institute Laboratories of Egerton University

2.4. Physicochemical Analysis

The samples were prepared in accordance with the AOAC 925.21 procedures [16]. Thereafter, analysis for butter fat (BF), protein, lactose, ash, solid not fat (SNF), density and milk freezing point (MFP) was performed by mid-infrared spectroscopic method [16] using milk analyzer Lactoscan® MCC30. Comparisons were performed by Garber method for milk BF%, Kjeldahl method for protein, the standard method for examination of dairy products was used to determine ash whereas lactose was estimated by getting the difference.

2.5. Experimental Design

Milk produced from dairy farms was delivered to Githunguri dairy farmers' cooperative society through nine routes. Out of the nine routes, three were randomly selected for purpose of this study. Thirty farms (sampling units) were selected randomly from the milk delivery routes based on a list of farmers provided by the cooperative society (sampling frame). A longitudinal survey was conducted where farms were nested within routes. Equal number of farms were selected per route based on supplementation of lactating cows with either LBY or CDM (LBY=15 farms; CDM=15 farms). Feeding and supplementation of the animals was conducted under supervision of the cooperative society extension staffs, agricultural extension officers and trial investigators. Baseline information was obtained during the first visit whereas milk samples were collected weekly from the farms during a 4-weeks period to assess effect of supplementation with or without LBY on physicochemical quality of milk.

2.6. Statistical Analysis

Descriptive statistics was used to provide a summary on data obtained from the farmers who participated in the study. A repeated measure analysis was performed using the Linear Mixed Models methodology by PROC MIXED of SAS [17]. Treatment was fitted as fixed effect while route, farm and farm nested within route were treated as random effects. After testing several Covariance Structures in the model, Autoregressive (AR1) was selected based on lowest AIC, AICC, and BIC values [18]. Least square means of study variables were adjusted by Tukey method and declared different at 5% level of significance.

3. Results

3.1. Livestock Management and Feeding Trend

About 37% of the farmers used feed troughs to estimate feeds offered to dairy cattle, 27% of them used gunny bags while 33% of the farmers did not estimated feeds at all. The findings indicated that most farmers (60%) supplement lactating cows at a uniform rate, 33% of them based level of supplementation on milk production but only 7% of the farmers supplemented cows using own assessment based on their levels of experience on dairy production. The amount of CDM fed to lactating dairy cows was estimated based on strategy of supplementation as indicated in table 1. However, LBY was supplemented by farmers at a uniform daily rate of 4 litres per cow per day (2 litres per milking).

Among the participating farmers, water used for domestic consumption and livestock was sourced based on priority from boreholes (70%), rivers (13%), rain water (10%) and dam (7%). Treated piped water was not mentioned by any farmer, an indication that water from the aforementioned sources was used in all farm operations.

Table 1. *Livestock management and feeding trends.*

Parameters	Categories	n	Percent (%)
Feeding systems	Stall feeding	28	93.0
	Stall feeding and grazing	2	7.0
Forage conservation methods	Hay	4	13.0
	Silage	9	30.0
	Hay and silage	1	3.0
	Crop residue drying	9	30.0
	No conservation	7	23.0
Forage feed estimation	Do not estimate	10	33.0
	Gunny bags	8	27.0
	Feed troughs	11	37.0
	Others	1	3.0
Strategy of supplementation	Uniform rate	18	60.0
	Based on milk production	10	33.0
	Others	2	7.0
Sources of water	Borehole	21	70.0
	Dam	2	7.0
	Rain	3	10.0
	River	4	13.0

n = number of farms

3.2. Physicochemical Criteria of Milk

The determination of physicochemical components in foods and especially in dairy products is important for both regulatory and nutritional information purposes. Least square means for supplementation regime effect on the physicochemical composition of milk samples are presented in Table 2.

Dairy cows supplemented with LBY produced milk of superior protein quality (3.07±0.03) compared to (2.99±0.03) for CDM fed cows. Conversely LBY fed cows produced milk of lower freezing point (-0.532±0.005°C) than CDM supplemented (-0.516±0.005°C) dairy cows. The remaining parameters tested in milk were not significantly influenced by the feeding regimes, although higher levels were observed on LBY supplemented diets than CDM diets.

Table 2. *Effect of liquid brewer's yeast on milk composition (Mean±SD).*

Parameter	Supplementation			Overall		
	CDM	LBY	Mean	RMSE	Max	Min
BF (%)	$3.69±0.06^{a}$	$3.75±0.06^{a}$	3.72	0.5	5.44	3.05
Protein (%)	$2.99±0.03^{a}$	$3.07±0.03^{b}$	3.03	0.19	3.74	2.01
Solid not fat (%)	$8.25±0.06^{a}$	$8.38±0.06^{a}$	8.32	0.46	10.25	7.1
Ash (%)	$0.67±0.004^{a}$	$0.68±0.004^{a}$	0.67	0.04	0.83	0.61
Lactose (%)	$4.5±0.03^{a}$	$4.58±0.03^{a}$	4.54	0.24	5.6	4.01
Freezing Point (°C)	$-0.516±0.005^{a}$	$-0.532±0.005^{b}$	-0.524	-0.041	-0.315	-0.672
Density (g/ml)	$1.029±0.0002^{a}$	$1.029±0.0002^{a}$	1.029	0.001	1.036	1.026

Different superscripts in the same row indicate statistically significant differences (p<0.05)

Kenya Bureau of Standards (KeBS) recommended raw milk components. Fat content: not less than 3.25%; protein content: not less than 3.5%; solids not fat: not less than 8.5%; density: 1.028 g/ml to 1.036 g/ml; freezing point: -0.525°C to -0.550°C and pH: 6.6 to 6.8 [19].

In the study, supplementation regimes had effect on parameters tested on route 1 but did not affect milk quality parameters tested in route 2 and 3. However, notable interaction between routes and supplementation trends was recorded in milk fat, protein, lactose and freezing point (Table 3).

Table 3. *Effect of LBY supplementation on milk quality from different delivery routes (Mean±SD).*

Parameters (%)	Supplementation					
	Route 1		Route 2		Route 3	
	CDM	LBY	CDM	LBY	CDM	LBY
Butter fat (%)	$3.46±0.34^{a}$	$3.92±0.61^{d}$	$3.85±0.50^{bd}$	$3.58±0.30^{abce}$	$3.77±0.50^{c}$	$3.76±0.55^{a-e}$
Protein (%)	$2.95±0.25^{a}$	$3.17±0.28^{b}$	$3.03±0.13^{ac}$	$2.97±0.07^{acde}$	$2.99±0.13^{acd}$	$3.06±0.19^{a-e}$
Solid not fat (%)	$8.24±0.32^{a}$	$8.61±0.75^{b}$	$8.30±0.35^{ac}$	$8.15±0.18^{ac}$	$8.20±0.34^{ac}$	$8.39±0.52^{abc}$
Ash (%)	$0.66±0.03^{a}$	$0.70±0.06^{b}$	$0.67±0.03^{ac}$	$0.66±0.01^{acd}$	$0.67±0.02^{a-d}$	$0.68±0.04^{acd}$
Lactose (%)	$4.46±0.21^{a}$	$4.71±0.41^{b}$	$4.54±0.19^{ac}$	$4.46±0.10^{acd}$	$4.50±0.14^{acd}$	$4.59±0.28^{a-d}$
Freezing point (°C)	$-0.50±0.064^{a}$	$-0.549±0.056^{c}$	$-0.526±0.025^{bc}$	$-0.515±0.013^{abde}$	$-0.520±0.020^{abde}$	$-0.532±0.038^{b-e}$
Density (g/ml)	$1.029±0.001^{a}$	$1.030±0.003^{b}$	$1.029±0.001^{a}$	$1.029±0.001^{a}$	$1.029±0.001^{a}$	$1.029±0.001^{a}$

Different superscripts in the same row indicate statistically significant differences (p<0.05)

4. Discussion

Milk protein percentage of Holstein Friesian cows fed LBY based diet was significantly (P <0.05) higher than cows supplemented with CDM. This is in concurrence with studies by Poppy *et al.* [20] and Shreedhar *et al.* [21], which indicated higher protein levels in milk from cows supplemented with yeast culture. The trial was conducted at a time when farmers in the study area relied mainly on purchased animal feeds or conserved feedstuff, mostly silage, dried crop residues and hay as presented in table 1. The high protein levels in milk from LBY supplemented cows in this study could be associated with improved nutritional value of poor quality forages, increase in number of rumen lactate-consuming bacteria and prevention of lactate accumulation [22]. Protein levels within the 3 milk delivery routes were similar; which could be an indication of nearly the same management practices. Major variations were recorded in the interaction between delivery routes and supplementation regimes, which may suggested that any significant changes observed in milk protein level were nutritionally dependent.

Milk freezing point was statistically significant (p<0.05) among supplementation regimes and their interaction with milk delivery routes. The decrease in MFP points to an increase in milk total solids (TS) [21] and has a significant correlation with curd characteristic. This positively translate to higher yield and consumer acceptance of popular dairy products such as yoghurt and cheese; leading to increase in profit margin by the dairy cooperative society, thereby increasing income of members at the end of financial year. Positive effect of yeast trial diet on milk components was equally recorded by Ayad *et al.* [23]. Adulteration of milk with water is one of the most likely factors that can affect MFP as it influences the concentration of water soluble components in milk. Earlier studies by Harding [24], indicated that adulterated milk will have a higher MFP closer to zero degrees centigrade. In case no addition of water is detected, then the difference in MFP could be due to different levels of concentration of milk components in the aqueous phase [25]. Nutritionally related MFP problem may only be possible in a situation where the cow is either starved or fed on poor quality diets with little or no grains [26]. Farmers in the study area practiced stall feeding with proper guidelines on balanced nutrition under constant supervision by field agricultural extension staff and the Cooperative society technical staff. The significant differences in MFP revealed in the interaction between supplementation regimes and milk delivery routes could be due to slight climatic variations in different delivery routes that may not necessarily be associated with supplementation regimes.

The levels of BF, SNF, ash, lactose and density were not significantly affected (p>0.05) by the type of supplementation regime as presented in Table 2, although superior milk components were reported on LBY supplemented cows. The positive effects of LBY diet on milk BF content concurs with the findings of Harris *et al*. [27] and Putnam *et al.* [28] that reported higher milk BF% on lactating dairy cows fed LBY based diet. Martin and Nisbel [29], associated the positive effect on milk BF% with increase in number of cellulolytic bacteria which enhances fiber degradation, thereby improving the digestibility of the diet and increase in proportion of acetic acids among the fermented Volatile fatty acids in the rumen. The level of SNF and ash were statistically similar between milk delivery routes. This can be attributed to the fact that milk tested in the study was from cows of the same breed, implying that they would be uniform in genetic composition. A relatively uniform level of SNF can be achieved as long as diets are balanced in nutrients with adequate roughages. However, feeding of high fiber and low energy rations can depress SNF content [30]. Majority (93%) of the participating farmers practiced stall feeding as shown in Table 1. Under the feeding system, all cows were fed as a single group and bulk milk samples tested. Nonetheless, a significant difference in the interaction between LBY supplementation regime and milk delivery routes was recorded. This could be an indication of differences in LBY sources between the milk delivery routes. The insignificant increase in lactose level for cows on LBY diet compared to CDM diet can be attributed to the fact that the study was conducted at a time of limited forage in the area and farmers had to purchase varied hay types from different sources with diverse quality to feed cows. The LBY supplementation could have contributed to stimulation of cellulolytic bacteria in the rumen, increase in fiber digestion and flow of microbial protein from the rumen [31]. This further confirms the suggestion by Bruno *et al*. [32] that feeding of yeast based diets improved milk lactose as compared to cows on control diets. In this study, the same levels of lactose percentage were recorded along the three different milk delivery routes. The results may suggest that apart from difference in supplementation regimes, forage quality and quantity fed within the sample routes were similar and could not affect lactose percentage. Milk density was similar among supplementation regimes, milk delivery routes and their interactions. The research outcome established that adulteration of milk was not commonly practiced by farmers in the study area.

5. Conclusions

The two supplementation regimes CDM and LBY affected physicochemical quality of milk in the study area. Higher Protein content and low freezing point was recorded in milk for cows supplemented with LBY compared to cows on CDM based supplement. The study indicated that LBY can be used successfully as a protein feed supplement in the dairy industry. Moreover, the hypothesized theory that use of LBY would lead to production of milk with inferior quality for process ability into different dairy products was nullified by the study results. Generally, physicochemical quality of milk delivered to Githunguri Dairy Farmers' Cooperative Society was good.

6. Recommendations

In view of the findings of this study, use of LBY as a cost effective alternative protein source for dairy cows is recommended. Additionally, there is need for capacity building to enable stakeholders in the dairy industry appreciate the importance of utilization of LBY as a cheaper protein source for dairy cows.

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