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ORIGINAL PAPER

# Evaluation of milk composition and fresh soft cheese from an intensive silvopastoral system in the tropics

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**Abstract** Intensive silvopastoral system (ISS) is a successful sustainable grazing system for dual-purpose cattle with growing adoption in the tropics; however, there is a concern on the quality of dairy products from this system. The aim of this study was to compare the ISS with the traditional monoculture system (MS) in terms of milk composition, soft cheese composition and yield, and the sensory acceptability of cheese during two seasons of a tropical area in Mexico. Twenty-four cows at the first 3 months postpartum were allocated evenly to two groups. The cows in ISS grazed in paddocks of *Leucaena leucocephala* associated with *Cynodon nlemfuensis* whereas the cows in MS grazed in *C. nlemfuensis*. Milk samples were collected weekly during the rainy and dry seasons for chemical analysis and fresh soft cheese making. The cheese was analyzed chemically, and cheese acceptability was evaluated for the sensory attributes of appearance, texture, flavor, color, and overall acceptability. Milk percentages of fat, protein, SNF, and lactose did not differ significantly between systems being, 3.5, 3.0, 8.1, and 4.4 in ISS and 3.6, 2.9, 8.0, and 4.4 in MS, respectively. Similar results were obtained for cheese content of fat/DM and protein/DM. In the rainy season, adjusted cheese yield from ISS (24.2%) was higher compared with MS (20.8%). Cheese texture in the dry season showed more acceptability for ISS. This study provide absence of adverse effect of ISS on milk and cheese composition; moreover, ISS improve the yield and acceptability of soft cheese.

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**Keywords** Milk composition · Fresh soft cheese · Intensive silvopastoral system · Cheese acceptability

## 1 Introduction

The trade in dairy products is expected to grow for the coming decade due to the increased human demand (OECD/FAO 2014). In human nutrition, milk and milk products are important, particularly cheese which is the most consumed milk-derived product. World consumption of cheese was 20,425 thousand tons in 2012 and expected to increase to 23,387 thousand tons in 2022 (OECD/FAO 2013). The largest trade of milk and dairy product consumption is in the form of fresh dairy products, representing up to 70% of total milk production of the world (OECD/FAO 2014). Fluid milk production in Mexico reached 11,129,921 thousand liters in 2014 (LACTODATA 2015), and 15% of this production is used for fresh type cheeses (SAGARPA/SIAP 2014).

In the tropics, milk production is mainly from the "dual-purpose systems", a system to produce milk (daily milking) and meat (calf after weaning) in the same herd (Rojo-Rubio et al 2008). Dual-purpose system is characterized by the use of crosses from *Bos taurus* × *Bos indicus* breeds and is based on grazing tropical pastures, which provide low-cost feeds to cattle (Pedraza-Beltrán et al 2012). It is well known that weather conditions determine seasonal variations in milk yield and composition, and this fact can modify cheese quality (FAO 2013; Solís-Méndez et al. 2013).

Intensive silvopastoral system (ISS) have been proposed as a sustainable strategy in the tropics to increase the availability and quality of forage across the year for meat and milk cattle production (Echevarría et al 2013). These type of systems are defined as intensive because of the sowing of a high density of forage shrubs such as *Leucaena leucocephala* (more than 10,000 plants.ha$^{-1}$) associated with improved grasses, e.g., *Panicum maximum* and *Cynodon nlemfuensis* among others (Cuartas-Cardona et al 2014). *L. leucocephala* is a tropical legume that has been successfully used in ISS, because of its nutritional value, adaptation to tropical conditions, as well as its environmental services such as carbon capture and nitrogen fixation (Cuartas-Cardona et al 2014). The association leucaena/grass support higher levels of milk production (Hernández Rodríguez and Ponce Ceballo 2004) and offers the possibility to certify milk and cheese as organic products ( Nahed-Toral et al 2013) with improved prices (Von Borell and Sørensen 2004; Solís-Méndez et al 2013). Sensory characteristics of cheeses can be defined as the human responses to perceptions of stimuli that are in the cheeses (Delahunty and Drake 2004). The nature of ingested forages by ruminants influence milk constituents and the sensory properties of dairy products; this is the case of carotenoids, responsible for the yellow color of dairy products (Coulon and Priolo 2002; Larsen et al 2013). Additionally, phenolic compounds such as indole and skatole can increase in milk when cows are grazing on pasture, which could affect the flavor of dairy products (O'Connell and Fox 2001). Actually, there is no clear view of the effect of consuming leucaena by the cows on the sensory properties of the produced milk or cheese. Stobbs and Fraser (1971) reported that leucaena can cause adverse effects on the flavor and odor in the milk, while in other study by Morillo and Faría-Mármol (1996), they did not realize this problem.

The objective of this study was to evaluate the chemical composition of the milk and the soft cheese as well as the cheese yield and acceptability from an intensive silvopastoral system based on *L. leucocephala* and *C. nlemfuensis*, during the rainy and the dry season in the tropics.

## 2 Materials and methods

### 2.1 Location and duration of the study

The study had two periods: the period I was the rainy season (July to October 2013) and the period II was the dry season (November 2013 to April 2014). It was carried out in the Campus de Ciencias Biológicas y Agropecuarias of the Universidad Autónoma de Yucatán (CCBA-UADY), Mexico, located at the east of the Yucatan Peninsula between the latitudes 16° 06′ and 21° 37′ north and longitudes 87° 32′ and 90° 23′ east. The region has a sub-humid tropical climate, with an average annual rainfall of 953 mm. The annual mean of temperature is 26.5 °C, with maximum and minimum ranges from 36 to 40 and from 14 to 16 °C, respectively (García 1988). Temperatures and rainfall were registered during the experiment and were taken from the microclimatic station at the CCBA-UADY (Fig. 1).

### 2.2 Animals management and treatments

There were used twenty four crossbred of Holstein and Brown Swiss × Zebu cows with European genes ranging from 50 to 75%. All the cows were multiparous (≥3 calvings) in the early postpartum (<3 months). The mean body weight was 526±56 kg and the body condition score was 6±0.3, according to the scale 1 (very thin) to 9 (very fat) (Ayala et al 1992). Treatments were established based on the feeding management as follows: the control group was the monoculture system (MS). This group ($n$=12) grazed in a paddocks of Stargrass (*C. nlemfuensis*) with a stocking rate of 2 AU.ha$^{-1}$ ([AU] 1 animal unit=450 kg live weight). The cows of this treatment were

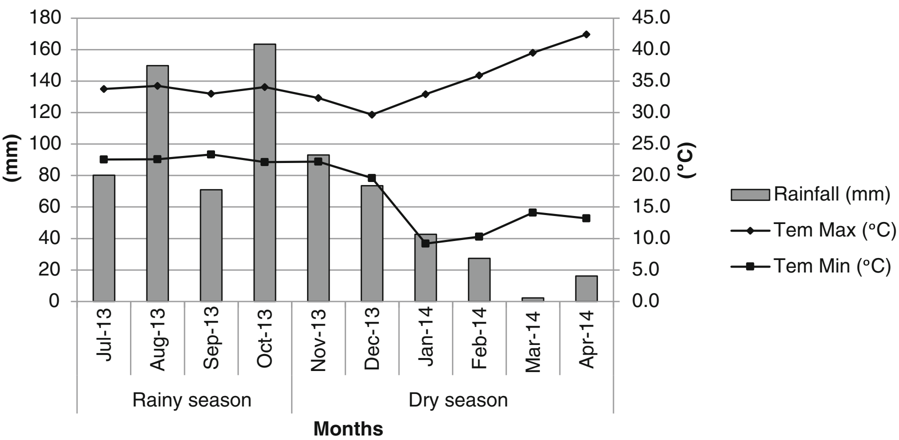


**Fig. 1** Temperature and rainfall during the experimental period

supplemented at milking with a concentrate based on ground corn grain 60%, soybean meal 30%, and soybean husks 10%.

The second treatment was the ISS: this group ($n$=12) grazed in mixed plots of *L. leucocephala* (36,000 leucaena plants.ha$^{-1}$) and Stargrass (*C. nlemfuensis*) at a stocking rate of 2.4 AU.ha$^{-1}$. The cows in this system were supplemented at milking with ground sorghum grain only.

The grazing times in both groups of cows were from 1700 to 0500 hours and from 0800 to 1300 hours. The two grazing systems had irrigation regularly during the dry season and during the other season as required. In order to allocate the supplement, records of milk yield of cows were checked and dry matter intake was previously estimated in the herd (Bottini-Luzardo 2015). The supplement in the two systems were offered to the animals to satisfy the protein and energy requirements (AFRC 1993). The concentrate and sorghum were offered in two equal portions at milking (0600 and 1500 hours). It was verified that all cows consumed the total amount of the respective supplement. The milking was mechanically, and the calf was used for few minutes before to stimulate the cow to let milk down. After milking, the calf was allowed to stay with the cow for 30 min, to take residual milk. Milk yield was recorded every month individually for the cows in each system. Samples of forage and supplements were taken monthly and analyzed for dry matter (AOAC 2012), crude protein by total nitrogen determination according to Dumas method using a LECO C'N analyzer (LECO Corporation 2014) (% protein = % N×6.25), and metabolizable energy was estimated according to MAFF (1975). Acid detergent fiber and neutral detergent fiber in forage samples were analyzed according to Van Soest et al (1991). Ether extract and ash were determined in the supplements with the methods of Tejada (1983) and AOAC (2012), respectively. The chemical composition of the forages and supplements is shown in Table 1. Grass dry matter intake was measured according to Dove and Mayes (1991). Table 2 summarizes the records of feed intake of the cows grazing the two systems during the two seasons.

**Table 1** Chemical composition (dry matter basis) of feedstuffs used for cows grazing a monoculture system (MS) and an intensive silvopastoral system (ISS)

| | MS | | ISS | | |
|---|---|---|---|---|---|
| | Concentrate | Stargrass | Sorghum | Stargrass | *L.leucocephala* |
| DM % (fresh matter basis) | 90 | 36.1 | 90 | 30.1 | 33.8 |
| CP % | 12.4 | 6.2 | 8.6 | 9.9 | 15.3 |
| ADF % | – | 37.0 | – | 36.2 | 24.8 |
| NDF % | – | 50.7 | – | 50.2 | 41.1 |
| CF% | 10.1 | – | 2.2 | – | – |
| EE % | 1.5 | – | 2.0 | – | – |
| Ash % | 3.8 | – | 1.4 | – | – |
| ME (MJ/kg DM) | 12.6 | 8.9 | 13.8 | 9.0 | 11.2 |

Adapted from Bottini-Luzardo (2015)

*DM* dry matter, *CP* crude protein, *ADF* acid detergent fiber, *NDF* neutral detergent fiber, *CF* crude fiber, *EE* ether extract, *ME* metabolizable energy

**Table 2** Daily dry matter intake (kg.cow$^{-1}$.day$^{-1}$) of dual-purpose cows grazing a monoculture system (MS) and an intensive silvopastoral system (ISS) during the rainy and dry seasons

| Season | Rainy | | Dry | |
|---|---|---|---|---|
| System | MS | ISS | MS | ISS |
| Sorghum | – | 4.79 | – | 7.5 |
| Concentrate | 5.5 | – | 2.9 | – |
| *L. leucocephala* | – | 5.38 | – | 6.3 |
| Stargrass | 7.3 | 3.71 | 7.2 | 2.8 |

Adapted from Bottini-Luzardo (2015)

## 2.3 Milk sampling and chemical analysis

Milk samples from each treatment (three liters) were obtained every week at the morning and afternoon milkings. Milk obtained from the afternoon milking was refrigerated at 5 °C and was then mixed thoroughly with milk from the morning milking to get a homogeneous sample per treatment. These samples were transferred to the laboratory for chemical analysis and for cheese making. There was taken 200 ml for milk analysis and 4 liters for cheese making. The numbers of samples obtained from each system were 42 (weeks) in total. Milk analysis for percentages of fat, total protein, lactose, and minerals were performed weekly during the two seasons using an automatic milk analyzer (Lactoscan MCC, Milkotronic 19944, Bulgaria). The equipment was calibrated for fat by the Gerber method (Kleyn et al 2001) and for protein by total nitrogen determination, according to the Dumas method using a LECO C'N analyzer (LECO Corporation 2014). Percentage of protein was expressed as: % N×6.38. pH in milk was measured using a pH meter (Hanna instrument pHep® HI 98107), which was calibrated with standard buffer solutions of pH 4.0 and 7.0.

## 2.4 Cheese manufacture

Fresh soft cheese (Domiati type) was made according to the method of Mehaia (2006) with modifications: milk was salted with sodium chloride at 3% (*w*/*w*), pasteurized at 73 °C for 15 s, and cooled to 40 °C. Then, microbial rennet (CUAMIX, CHR-HANSEN, Mexico) was added and mixed thoroughly. The milk was maintained at 40 °C until coagulation. After that, the curd was scooped into cheese cloth, drained for 2 days in a cooler at 5 °C, then cheese was taken out of the cheese cloth and weighed. A cheese sample of 200 g was taken for chemical analyses and frozen at −18 °C until analyses. For sensory evaluation, fresh samples of cheese were taken at the end of every season.

## 2.5 Chemical analysis of the cheese

Moisture (M) content was determined by drying 2 to 3 g of cheese at 105 °C until constant weight (AOAC 2012). Cheese dry matter (DM) was calculated as 100−% moisture. Cheese fat content was measured using the Gerber method (AOAC 2012). Fat in dry matter (Fat/DM %) was calculated by the formula Fat/DM %=(Cheese fat

%×100)/Cheese DM %. Salt content of cheese was determined using the Mohr titration method (Nielsen 2010). Salt in moisture (Salt/M%) was calculated by the formula Salt/M%=(Cheese salt %×100)/Cheese M %. Cheese total nitrogen determination was made by the automated Dumas dry combustion method using a LECO C-N analyzer (LECO Corporation 2014). Percentage of protein was expressed as % N× 6.38. Protein in dry matter (Protein/DM %) was calculated by the formula Protein/DM %=(Cheese protein %×100)/cheese DM %. The ashes were determined by incineration of about 3 g sample in a furnace oven at 550 °C for 4 h (AOAC 2012).

### 2.6 Cheese yield calculations

Actual cheese yields were calculated as the weight of cheese divided by the weight of milk used and expressed as kg.100 $kg^{-1}$ milk. The actual cheese yields varied markedly especially in soft cheese due to the variations in moisture and salt content as reported by Mehaia (2006); therefore, cheese yields were adjusted to a standard moisture and salt content for statistical analysis using the average moisture and salt content of the soft cheese obtained in this experiment (70.48 and 2.69%, respectively). Adjusted cheese yield was calculated by the following formula Mehaia (2006):

$$\text{Adjusted yield }\% = \text{actual cheese yield }\% \times (100-(\text{actual cheese moisture }\% + \text{actual cheese salt }\%)) \div (100-(70.48+2.69))$$

### 2.7 Sensory evaluation of the cheese

Cheese sensory evaluation was performed by 15 test panelists familiar with Domiati cheese. There was used a scoring test with the aid of a nine point hedonic scale (where 9=like extremely, 5=neither like nor dislike, and 1=dislike extremely) to determine the cheese acceptability. The sensory attributes of appearance, texture, flavor, color, and overall acceptability were examined as described by Mehaia (2006). Cheese samples were randomly coded and presented to each panelist at 20 °C. Data collected from panelists were subjected to statistical analysis.

### 2.8 Experimental design and statistical analysis

A 2×2 factorial design with season and system of production as fixed factors was used. The response variables (milk and cheese composition) were analyzed by analysis of variance using a two-way ANOVA with the model $Y_{ijk}=\mu+T_i+S_j+(TS)_{ij}+\varepsilon_{ijk}$, where $Y_{ijk}$ is the dependent variable, $\mu$ is the general mean, $T_i$ is the effect of $i$th system ($i$=MS, ISS), $S_j$ is the effect of $j$th season ($j$=rainy, dry), $(TS)_{ij}$ is the effect of the interaction between system and season, and $\varepsilon_{ijk}$ is the residual error, using the GLM procedure of SPSS Statistics 22 (SPSS for windows 2013). Interaction effect was removed from the final model when it was not significant ($P>0.05$), and the principle effect was evaluated. For the sensory analysis, one-way ANOVA was used for every season separately and the system of production as fixed factor. In addition, Pearson's correlation coefficients were calculated between milk components and the adjusted cheese yield separately for the two systems.

## 3 Results

### 3.1 Milk composition

The composition of the milk from the evaluated systems is shown in Table 3. It was not found any effect of the system on milk composition. Percentages of fat, protein, solids not fat (SNF), total solids, lactose, and minerals were all significantly higher ($P<0.05$) in the dry season for the MS and ISS. The pH was higher ($P<0.05$) in the milk from the rainy season than that of the dry season. Interactions between season and system concerning to all milk compositional variables were not significant (Table 3).

### 3.2 Fresh soft cheese composition

Table 4 shows the chemical composition and the adjusted yield of fresh soft cheese made in the rainy and in the dry seasons from MS and ISS. No significant differences ($P>0.05$) were detected between systems regarding the cheese percentage of DM, fat/DM, protein/DM, salt/M, ash, and cheese yield adjusted. Cheese made during the dry season showed higher content ($P<0.05$) of fat/DM, protein/DM, and cheese yield adjusted than the cheese made during the rainy season.

For cheese yield adjusted, a significant interaction ($P<0.05$) between season and system was observed. The source of the interaction is shown in Fig. 2. The cheese yield was higher for ISS during the rainy season comparing with MS in the same season ($P<0.05$), while no difference between systems was found in the dry season. There were no differences for season or for system regarding to the cheese salt/M or ash percentage ($P>0.05$).

**Table 3** Milk yield (L.cow$^{-1}$.day$^{-1}$) and milk composition (mean %) of dual purpose cows as affected by grazing season and system

| Season | Rainy | | Dry | | SEM | *P* | | |
|---|---|---|---|---|---|---|---|---|
| System | MS (*n*=16) | ISS (*n*=16) | MS (*n*=26) | ISS (*n*=26) | | Season | System | Interaction |
| Milk yield | 16.3 | 10.1 | 14.2 | 18.5 | | | | |
| Fat | 3.4 | 3.3 | 3.7 | 3.6 | 0.05 | ** | NS | NS |
| Protein | 2.9 | 2.9 | 3.0 | 3.0 | 0.01 | *** | NS | NS |
| SNF | 7.9 | 7.9 | 8.1 | 8.2 | 0.03 | *** | NS | NS |
| Total solids | 11.2 | 11.3 | 11.8 | 11.8 | 0.07 | *** | NS | NS |
| Lactose | 4.3 | 4.4 | 4.5 | 4.5 | 0.02 | *** | NS | NS |
| Minerals | 0.64 | 0.65 | 0.66 | 0.67 | 0.003 | *** | NS | NS |
| pH | 6.8 | 6.8 | 6.7 | 6.6 | 0.01 | *** | NS | NS |

*P* statistical significance, *NS* nonsignificant, *MS* monoculture system, *ISS* intensive silvopastoral system, *n* number of the weeks, *SNF* solids not fat, *SEM* standard error of mean

*$P<0.05$; **$P<0.01$; ***$P<0.001$

**Table 4** Fresh soft cheese composition and adjusted yield (mean %) as affected by grazing season and system

| Season | Rainy | | Dry | | *P* | | | |
|---|---|---|---|---|---|---|---|---|
| System | MS (*n*=16) | ISS (*n*=16) | MS (*n*=26) | ISS (*n*=26) | SEM | Season | System | Interaction |
| DM | 26.4 | 27.5 | 31.1 | 30.8 | 0.45 | *** | NS | NS |
| Fat/DM | 41.6 | 40.8 | 46.7 | 44.9 | 0.51 | *** | NS | NS |
| Protein/DM | 32.7 | 33.1 | 34.9 | 36.4 | 0.41 | *** | NS | NS |
| Salt/M | 3.7 | 3.9 | 3.8 | 3.8 | 0.03 | NS | NS | NS |
| Ash | 3.4 | 3.5 | 3.5 | 3.7 | 0.07 | NS | NS | NS |
| Cheese yield adjusted | 20.8 | 24.2 | 24.7 | 23.9 | 0.34 | ** | NS | ** |

*P* statistical significance, *NS* nonsignificant, *MS* monoculture system, *ISS* intensive silvopastoral system, *n* number of the weeks, *DM* dry matter, *M* moisture, *SEM* standard error of mean

*$P<0.05$; **$P<0.01$; ***$P<0.001$

### 3.3 Correlation between milk components and fresh soft cheese yield

Table 5 shows the correlation coefficients between the major milk components and the adjusted fresh soft cheese yield from MS and ISS. In MS, milk fat and total solids were highly positively correlated with cheese yield adjusted ($r$=0.71 and 0.73, respectively). Protein content and SNF were also positively correlated with the adjusted soft cheese yield, but with a lower correlation value ($r$=0.38 for the both components). Similarly, lactose and minerals presented a low correlation value of 0.36 and 0.34, respectively.

In ISS, fat and total solids were the components with higher correlations with the adjusted cheese yield ($P<0.01$) with values of 0.64 and 0.71, respectively. Milk protein, SNF, lactose, and minerals had lower correlation values with the adjusted cheese yield, being 0.5, 0.49, 0.49, and 0.45, respectively.

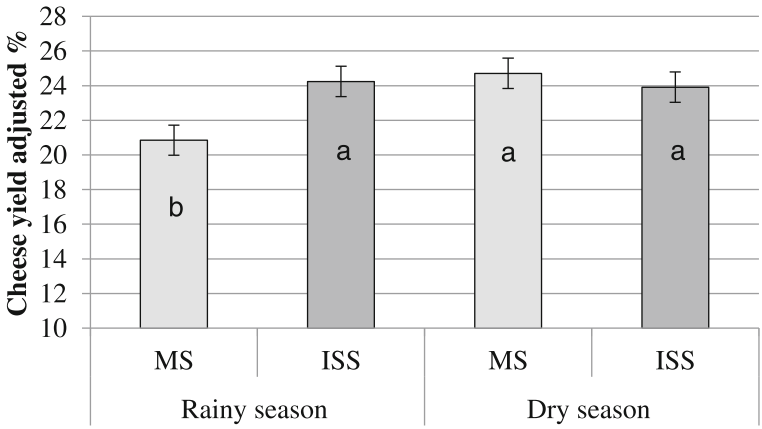


**Fig. 2** Effect of system and season on the fresh soft cheese yield adjusted %. *Different letters* (*a*, *b*) are significantly different ($P<0.05$). *MS* monoculture system, *ISS* intensive silvopastoral system

**Table 5** Pearson correlation coefficients between major milk chemical components and fresh soft cheese yield from the intensive silvopastoral system (ISS) and monoculture system (MS)

| | | Correlations for MS (n=42) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fat | Protein | SNF | TS | Lactose | Minerals | Cheese yield adjusted |
| Correlations for ISS (n=42) | Fat | | 0.25 | 0.25 | 0.90** | 0.20 | 0.22 | 0.71** |
| | Protein | 0.31* | | 0.99** | 0.65** | 0.99** | 0.99** | 0.38* |
| | SNF | 0.30* | 0.99** | | 0.65** | 0.99** | 0.99** | 0.38* |
| | TS | 0.89** | 0.71** | 0.71** | | 0.61** | 0.63** | 0.73** |
| | Lactose | 0.31* | 0.99** | 0.99** | 0.71** | | 0.99** | 0.36* |
| | Minerals | 0.31* | 0.98** | 0.97** | 0.69** | .976** | | 0.34* |
| | Cheese yield adjusted | 0.64** | 0.50** | 0.49** | 0.71** | 0.49** | 0.45** | |

*Correlation is significant at the 0.05 level; **correlation is significant at the 0.01 level

*n* number of the weeks, *SNF* solids not fat, *TS* total solids

## 3.4 Sensory evaluation of fresh soft cheese

Results of the sensory evaluation for fresh soft cheese from MS and ISS during the rainy and the dry season are shown in Fig. 3. There were no significant differences in all the sensory attributes of the cheese from MS and ISS in the rainy season. Similar results were found in the cheese from the dry season except a significant better acceptability for texture ($P<0.05$) was found in the cheese from ISS.

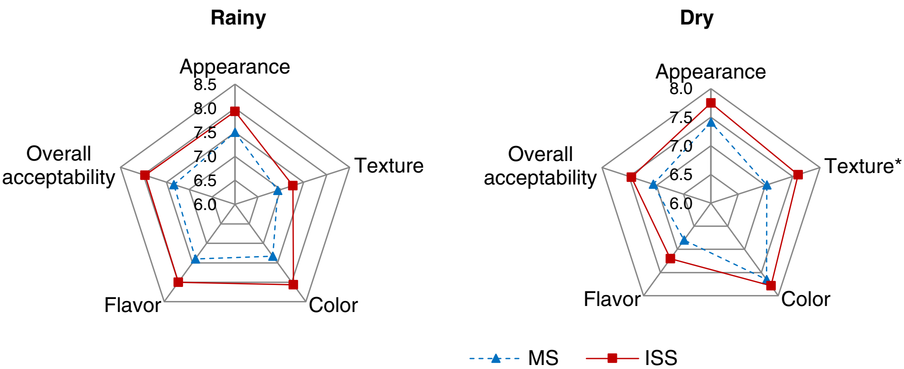


**Fig. 3** Sensory scores of fresh soft cheese made in monoculture system (MS) and intensive silvopastoral system (ISS) during the rainy and dry season. *$P<0.05$

## 4 Discussion

### 4.1 Milk composition

Concerning to milk fat, protein, and lactose, similar results were found in a previous study with similar experimental conditions by Peniche-González et al. (2014). Those authors suggested that the absence of difference in milk composition between treatments could have been due to a similar supply of milk precursors to the mammary gland of the cows. Our results also are in agreement with Solís-Méndez et al. (2013) for the content of protein, lactose, and pH, and with the findings of Faría-Mármol et al. (2007) who did not find significant differences in milk fat or milk protein percentage when 50 to 75% of concentrate feed was replaced by grazing a leucaena bank for 2 h.day$^{-1}$.

In general, milk components were higher in the dry season than the rainy season for the two systems. In the MS, the increase in milk components can be associated to the reduction in milk yield in the dry season, resulting in a concentration of milk components (Todaro et al 2014). In the ISS, the higher milk components in the dry season could not be explained by a concentration effect, because milk yield was higher during this season. This result could be related to the higher intake of *L. leucocephala* and the lower intake of stargrass during the dry season (Table 2), which could lead to a better fiber digestibility of the diet considering the lower contents of ADF in leucaena in comparison to the stargrass (Barros-Rodríguez et al 2012). In this context, (Ruiz-González 2013) reported a significant increase in milk fat content from 3.84 to 4.05% when the inclusion of *L. leucocephala* increased from 15 to 30% in the diet. In agreement to the present study, Hernández Rodríguez (2005) reported an increased milk fat content in the dry season when the cows grazed a silvopastoral system similar to our study (*L. leucocephala* and *C. nlemfuensis*).

There was no significant interaction between season and system regarding all milk components which agreed with La Terra et al (2012). The pH values in the two systems were in the natural range for fresh milk (between 6.5 and 6.8) (Fox and McSweeney 1998). The slight lower pH in milk during the dry season could be attributed to the increase in the environmental temperature in this season specifically March and April as shown in Fig. 1.

### 4.2 Fresh soft cheese composition and yield

The lack of differences in cheese composition between MS and ISS could be explained by the absence of differences in milk composition between systems. However, there was a significant interaction between the season and the system reflected in a higher adjusted cheese yield from ISS during the rainy season. This result is relevant and means that ISS could be a good option for the cheese maker in tropical areas, especially during the rainy season, where cheese yield has been reported to be lower (Solís-Méndez et al 2013).

Similar results was found by EL-Sheikh et al (2011) who reported higher yield of Domiati cheese (32.73%) when using leucaena leafs as a source of 30% of protein requirements in the feeding system of dairy buffaloes comparing with sunflower meal

(29.93%). These values are higher than our values in the present study, while this could be attributed to the differences of the type of milk.

The higher content of milk solids in the dry season, particularly fat and protein was reflected in the cheese percentages of dry matter, fat/DM, protein/DM and adjusted cheese yield which were all higher in the dry season. Hattem et al (2012) stated that the difference in milk casein and fat in total is the major factor responsible for the change in the cheese yield; in addition, seasonal changes have significant impacts on cheese composition and cheese yield. That assumptions have been reported for several types of cheeses such as “Tepeque” cheese, a traditional cheese made in the east of Mexico ( Solís-Méndez et al 2013), Ras cheese in Egypt (Hattem et al 2012) and hard-pressed ovine cheese in the USA (Jaeggi et al 2005).

On the other hand, the absence of differences in the treatments for salt/M % can be attributed to the fixed percentage of salt used in the cheese making (3%).

### 4.3 Correlation between milk composition and fresh soft cheese yield

As mentioned before, fat and protein in milk are the main components that affects the cheese yield ( Verdier-Metz et al 2001; Soryal et al 2004; Jaeggi et al 2005; Hattem et al 2012). In MS, fat content was more correlated to the adjusted fresh cheese yield than in ISS. Milk protein and lactose also presented the same trend but with low correlation values. Soryal et al (2004) reported similar results with the same type of cheese but from goat milk. They found that milk fat content was more highly correlated to cheese yield than milk protein content ($r$=0.60 vs 0.38, respectively).

### 4.4 Sensory evaluation of fresh soft cheese

Sensory properties of milk can be affected by composition of forage as well as proportion of forage to concentrate. If such type of milk is used for production of dairy products, product composition as well as sensory properties could be affected (Larsen et al 2013). Nozière et al (2006) reported clear effect of consumption of green forages by the cows on the increases of the β-carotene content in milk and cheese, which is responsible of the yellow color. In this respect, Lamchoun (1998) reported high β-carotene content of leucaena leaf of 116–161 mg.kg$^{-1}$ DM comparing with other types of grass. In the present study, acceptability in the cheese sensory attributes of appearance, color, flavor, and overall acceptability were found to be similar between the ISS and MS during the two grazing seasons. This result could be attributed to the similarity in gross chemical composition of the cheese between the two treatments, especially the fat content, where Soryal et al (2004) associate the adverse effect on the cheese flavor score with milk fat content in fresh Domiati cheese. In another study, Morillo and Faría-Mármol (1996) did not show any significant effect on the odor or the color of the milk when the cows consumed leucaena.

There was found higher texture acceptability ($P$<0.05) of the cheese from ISS compared with cheese from MS during the dry season. Similar results were reported by EL-Sheikh et al (2011) who found high body and texture score of the fresh soft cheese (Domiati type) when using leucaena leafs as source of 30% of protein requirements in the feeding system of dairy buffaloes comparing with Sunflower meal.

## 5 Conclusions

Milk and fresh soft cheese characteristics from the ISS with *L. leucocephala* and *C. nlemfuensis* were similar to that produced from the MS of *C. nlemfuensis*. The ISS could be a good alternative to improve cheese yield in the tropics. Cheese from ISS was well accepted and showed higher preference for texture in relation to the cheese from MS.

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**Conflict of interest** Asmaa H. M. Mohammed, Carlos F. Aguilar-Pérez, Armín J. Ayala-Burgos, María B. Bottini-Luzardo, Francisco J. Solorio-Sánchez, and Juan C. Ku-Vera declare that they have no conflict of interest.

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