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Effects of dietary cowpea (*Vigna sinensis*) hay and protein level on milk yield, milk composition, N efficiency and profitability of dairy cows

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ABSTRACT

Thirty-two lactating Holstein cows were grouped by days-in-milk into 8 blocks of 4 cows and fed 4 diets containing either (dry matter (DM) basis) 0 or 125 g/kg of cowpea hay (*Vigna sinensis*), added at the expense of sorghum silage, with either low (155 g/kg) or high (170 g/kg) crude protein (CP) supplemented as soybean meal and distillers grains. Diets were balanced to be isoenergetic for cows weighing 540 kg and producing 29 kg/d of milk. Cows were milked and fed ad libitum 3 times a day. The experiment was conducted as a 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments; periods were 21 days long with 14 days of adaptation and 7 days of data collection and sampling. Effects of cowpea, CP and their interactions were evaluated using the mixed procedures of SAS, with either pen (traits related to intake) or cow (traits related to production) as the experimental unit. No significant effects of treatment were observed for DM intake (DMI), body weight (BW) gain, and yield of milk and milk components. However, substituting cowpea hay for a portion of the dietary sorghum silage increased milk/DMI and milk N/N intake and decreased milk urea N (MUN) and fecal N excretion, tended to decrease urinary N excretion, reduced feed cost and increased income over feed cost. Moreover, feeding of cowpea hay increased apparent total tract digestibility of DM, organic matter, CP and neutral detergent fiber. Decreasing dietary CP from 170 to 155 g/kg increased Milk N/N intake and decreased MUN, urinary N, fecal N and urinary N/N intake, reduced feed cost and increased income over feed cost. Inclusion of cowpea hay in diets formulated under tropical conditions reduced the need to feed high-cost protein ingredients, improved feed and N efficiency, and reduced risk of N pollution.

1. Introduction

Tropical and subtropical grasses have high fiber content and low digestibility (Juarez Lagunes et al., 1999), which highlights the need for alternative forages to help achieve better productivity and profitability. Legumes such as alfalfa (*Medicago sativa)*, red clover (*Trifolium pratense*) and white clover (*Trifolium repens*) are often fed in temperate regions to improve nutrient contribution, mainly protein, from forage. These species have been shown to increase dry matter (DM) intake and milk yield in dairy cows (Broderick et al., 2002; Dewhurst et al., 2003a) and digestibility (Dewhurst et al., 2003b). However, their cultivation and use in warmer climates

Abbreviations: BW, body weight; CP, crude protein; DM, dry matter; DMI, dry matter intake; FCM, fat-corrected milk; IOF, income over feed cost; MUN, milk urea N; NDF, neutral detergent fiber; OM, organic matter; TMR, totally mixed ration

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is not feasible because these forages are unadapted to tropical and subtropical pests and diseases. Ensiled forage from warm season legumes such as cowpea (*Vigna* spp.), perennial peanut (*Arachis glabrata*) and annual peanut (*Arachis hypogaea*) were evaluated in Florida for nutritive content by Foster et al. (2011) and, based on greater CP content and *in situ* DM and neutral detergent fiber (NDF) digestion compared to bahiagrass haylage, the authors concluded that these were promising forages for dairy cows in the sub-tropical US.

Studies addressing the optimization of dietary protein have shown that concentrations beyond 160 g/kg CP do not positively impact milk yield (Groff and Wu, 2005; Olmos Colmenero and Broderick, 2006). Salvadoran dairy farmers often overfeed CP: A survey in Central and Western El Salvador of 8 dairies using free-stall management of Holstein cows indicated that rations averaged 171 g CP/kg DM over both the dry and rainy seasons; a ration with 196 g CP/kg DM was fed on one farm during the rainy season (Zavala et al., 2012). Overfeeding CP reduces profit margins due to the relatively high cost of protein supplements and low efficiency of N use by dairy cows fed high protein diets (Broderick, 2003). Dairy cows excrete about 2–4 times more N in manure than they secrete in milk, which increases both cost of milk production plus environmental N pollution (Broderick, 2006).

Our hypotheses were that 1) reducing dietary CP below 170 g/100 kg DM, the typical concentration fed by Salvadoran dairy farmers, would not impair production, and 2) feeding a tropical legume forage would lower feed cost. This study evaluated feeding cowpea hay (*Vigna sinensis*), a tropical legume, at two levels of CP in the diet of lactating dairy cows under tropical conditions for yield of milk and milk components, nutrient efficiency and profitability.

2. Material and methods

2.1. Cows and design

The study was conducted at El Milagro dairy farm in Sonsonate Department, El Salvador, at an altitude of 425 m, Latitude 13.745°, Longitude −89.633°, with 26 °C average daily temperature and 1900 mm average annual rainfall. Twenty-two primiparous Holsteins with mean (± SD) 100 ± 4.7 days-in-milk, 531 ± 62 kg body weight (BW) and 27 kg ± 4.6 milk/d, plus 10 multiparous Holsteins with mean (± SD) parity 3.2 ± 1.5, 96 ± 59 days-in-milk, 585 ± 73 kg BW and 33 ± 4.3 kg milk/d. All cows used in the trial had body condition scores ranging from 3.5 to 3.75 and normal health histories. The cows had free access to water, were milked 3 times a day (07:00, 15:00 and 23:00) and fed after each milking. Heat stress was controlled using 91 cm fans and water sprinklers with continuous fan ventilation from 09:00 to 17:00 and with 2 min of sprinkling every 10 min. The pens were sand-floored free-stalls and cows had access to 95 cm of linear feed bunk space per animal. The experimental procedures applied to animals were approved by the Research Council of the University of El Salvador, which is the authority in this matter.

For data related to production and N-metabolism in which cow was the experimental unit, cows were blocked by parity and DIM into 8 squares of 4 cows (4 squares of primiparous cows, 2 squares of multiparous cows and 1 square with 2 primiparous cows and 2 s lactation cows). However, for data related to DMI in which pen was the experimental unit, 1 cow from each square was randomly assigned to 1 of the 4 pens (total 8 cows/pen). Treatments were applied in a 2 × 2 factorial arrangement in each Latin square; the 4 periods were 21 d long (total 84 d) with 14 d for adaptation and 7 d for data collection and sampling. Experimental diets were fed as total mixed rations (TMR) to all animals in a pen and diets were switched among pens at the end of each period. This arrangement of diets and pens over periods has yielded satisfactory results in previous studies (Aguerre et al., 2012; Swanepoel et al., 2014). Experimental diets were formulated to contain (DM basis) 500 g/kg of forage and 500 g/kg of concentrate plus mineral mix and either 0 of 125 g/kg of cowpea hay, which was added at the expense of sorghum silage. Furthermore, diets contained either low (155 g/kg) or high (170 g/kg) CP, with the additional CP from soybean meal and distillers grains added at the expense of wheat bran and corn meal. Compositions of the sorghum silage and cowpea hay are in Table 1 and of the 4 experimental diets are in Table 2. All diets were balanced to 11.0 MJ ME/kg DM using the CPM Dairy V3® program to meet the energy requirements for dairy cows weighing 540 kg and producing 29 kg/d of milk. Feeding rate was adjusted daily to yield refusals equivalent of about 100 g/kg of feed offered. The TMR were sampled every week to determine DM content of the as-fed TMR to compute DM intake (DMI).

2.2. Data collection and sampling

Daily amounts of feed offered and refused on a pen basis and milk production of each cow at every milking were recorded during

Table 1
Chemical composition of the cowpea hay (*Vigna sinensis*) and sorghum silage fed to the dairy cows.

Trait	Cowpea hay		Sorghum silage	
	Mean	SEM[a]	Mean	SEM
Dry matter, g/kg	874	5.0	285	10.8
Ash, g/kg DM	113	2.3	99	1.6
Organic matter, g/kg DM	890	2.3	901	1.6
Crude protein, g/kg DM	166	3.1	84	1.9
Neutral detergent fiber, g/kg DM	464	14.8	548	12.5

[a] Standard error of the mean.