



Productive and economic response to partial replacement of cracked maize ears with ground maize or molasses in supplements for dual-purpose cows



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Abstract:

The aim of the study was to assess the effect of partial replacement of cracked maize ears with ground maize (GM) or sugar cane molasses (SCM) in supplements for dual purpose cows. Eighteen (18) multiparous cows (414 ± 13 kg of body weight and 106 ± 32 d in milk) were randomly assigned to the treatments. Treatments were as follows: 1) Control supplement (CS) which consisted of 87% of cracked maize ears (CME), 11% soybean meal, and 2% urea; 2) Ground maize replacing 20% of CME in CS (GMS); 3) Sugar cane molasses replacing 18% of CME in the CS (MOS). Each cow received 5 kg/d of

supplement DM, whereas their calves received 1.8 kg/d DM of the CS. The experiment lasted eleven weeks, and data were recorded once at the end of every week. Data were analysed using a linear mixed model as a completely randomized design. Net profit from milk and beef due to supplements were estimated using the partial budget approach. There were no differences ($P>0.05$) between treatments on milk composition, body conditions score, nor daily weight gain of cows and calves. However, compared to GM, CS shown greater (9.0 %, $P<0.05$) dry matter intake and SCM shown greater milk yield (18.6 %, $P<0.05$). Partial replacement of cracked maize ears with ground maize or sugar cane molasses, in supplements for dual purpose cows, did not affected animal productive response. However, considered the combined net profit margins (milk and calves), SCM got an average of 9 % higher profits compared of the rest of supplements.

Key words: Milk, Beef, Brown Swiss, Tropical Grasses, Energy supplementation.

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Introduction

Dual-purpose (DP) bovine production, in tropical regions of Mexico and Latin America, rely on the use of local resources like grasses, shrubs and trees under extensive management. In the south west of the State of Mexico as well as in most tropical regions of México, cattle feed exclusively on forages under extensive grazing during the rainy season. During the dry season (December to May), the availability and nutritional quality of forages decreases considerably. To minimize the impact of the low forage availability and to the diminished quality of forages, farmers supplement their cattle with variable amounts of supplement (5 to 9 kg DM/cow/d)⁽¹⁾.

Farmers' decision on the amount of supplement offered to each cow, and the time to start supplementation during the dry season, depends on the availability of forage on pastures. The second half of the dry period (March to May) is the most critical for farmers, since forage in pastures becomes scarce, so that farmers use supplements to sustain animal production^(1,2).

Metabolizable energy has been reported as one of the main constrains for cattle production under tropical conditions due to the low nutritional value of forages (due mainly to high fibre content)⁽³⁾.

Supplements represent between 50 to 70 % of milk and beef production costs. Due to supplementation, milk production costs increase 22 % in the dry season, in comparison to the rainy season, reducing the already slim profit margins^(1,2).

In order to keep supplement costs as low as possible, harvested maize ears produced in the farm are cracked instead of being ground, in order to reduce processing cost. However, total digestibility of cracked maize ears is lower (87.6 %), compared with ground maize (91.7 %)⁽⁴⁾. Frequently, un-degraded large particles of maize appear in faeces representing a waste and inefficient use of this resource.

Maize starch is the most common source of energy for dairy cattle, that degrades between 4 to 6.4 %/h. Carbohydrate sources with faster degradation rates than maize may improve ruminal conditions, resulting in better animal productive response to supplementation⁽⁵⁾.

Sugar cane molasses is a readily source of energy, that has been used in supplements for cattle feeding on low quality grasses in tropical regions^(6,7,8). However, despite availability and relatively low cost, farmers in the study region do not incorporate this resource in their cattle supplements.

The inclusion of sugar cane molasses under *in vitro* studies improves fibre digestibility of a combination of star grass (*Cynodon nlemfuensis*) and *Leucaena leucocephala*; whereas the inclusion of maize grain increased *in vitro* volatile fatty acids production⁽⁹⁾. Furthermore, addition of sugar cane molasses to supplements based on maize silage, improved growing rates of heifers under tropical conditions, reducing production costs at the same time⁽⁶⁾.

The aim of this experiment was to evaluate the productive and economic response of partial replacement of cracked maize ears (control supplement) with ground maize (20 % inclusion) (GM), or sugar cane molasses (18 % inclusion) (SCM), in supplements offered to grazing dual purpose Brown Swiss cows during the dry season in a subtropical region of Mexico.

Material and methods

Area description

The study was performed in a commercial dual purpose farm in the State of Mexico, at 19° 04 '48" N and 100° 13' 18" W, and an altitude of 1,470 m. Climate is subtropical (warm sub-humid), with a mean annual temperature of 23 °C, and 1,115 mm mean annual rainfall.

Experimental farm

The participating farm is of typical characteristics of DP of the region. Resources, management and socioeconomic characteristics have been described⁽¹⁾. Briefly, the farm produces milk all year round, and milk and calves sales represent 42 and 44 % of annual incomes, respectively. Daily milk incomes cover daily expenses of farm operation, and the economic needs of the farming family. Calves are sold at 18 mo old, usually by the end of the rainy season. Farm land extension is 100 ha and the perimeter fenced, with no subdivisions, where cattle graze all year round. Usually, around 35 milking cows and their calves plus a sire are kept as a single herd, whereas replacements, are kept on a different location. Cattle feed exclusively on forages during the rainy season, receiving only mineral supplementation. During the dry season, cows are supplemented with a mixture of cracked maize, and soybean meal (~5 kg/cow/d DM).

Animals and management

Eighteen (18) multiparous Brown Swiss cows (414 ± 13 kg weight and 106 ± 32 d in milk) were randomly allocated to one of three treatments (six cows per treatment).

Experimental cows grazed with the rest of the herd. Stocking rate was 0.25 animal units (AU) per ha. Cows had access to *ad libitum* water and minerals. Milking of cows was manually from 0700 to 0900 h once a day. Before milking, the calf was allowed to suckle for few seconds the first milk for let-down, and then tied to the cow's neck until the end of milking. Afterwards, calves suckled the residual milk and remained with their dam in grazing areas until 1400 h.

After been separated from their dams, calves remained in a different paddock until the next morning, where they grazed on a pasture of similar characteristics as the cows. Calves received 1.8 kg DM/d of control supplement (CS) (Table 1), and had access to water and a mineral mix *ad libitum*.

Table 1: Ingredients and chemical composition of control (CS), ground maize (GM), and sugar cane molasses (SCM) supplements (g/kg DM)

	CS	GM	SCM	SEM
	Ingredient composition:			
Cracked maize ears	866	696	693	
Soybean meal	111	81	107	
Ground maize		200		
Molasses			177	
Urea	23	23	23	
	Chemical composition:			
Dry matter	873	870	849	4.1
Crude protein	124	113	119	14.4
Neutral detergent fibre	379	218	214	2.7
Acid detergent fibre	55.7	63.0	48.9	0.6
Lignin	11.0	11.5	11.4	8.5
Dry matter digestibility	903	908	940	5.2
Organic matter digestibility	895	901	933	11.3
NDF digestibility	792	715	809	3.2
Metabolizable energy, MJ/kg DM	14.1	14.1	14.6	16.1
Solubles (a)	59.8	46.5	68.1	
Solubles rate (0-1)	0.098	0.128	0.153	
Insoluble (b)	256.8	274.2	255.7	
Insolubles rate (0-1)	0.062	0.067	0.065	
Lag (h)	5.8	5.5	4.2	

From a previous study (unpublished), calves consumed on average 3.0 kg of milk estimated by weight differences before suckling (0900 h milking) and after removal from their dams (1400 h).

The management of cows and calves during the experiment was minimal in order to avoid stress in the animals, and not to interfere with the farmer's daily activities. Therefore, cows and calves were weighted once a week.

Treatments

The control supplement (CS) was based on cracked maize ears (CME) (husk, kernels and cob) (86.6 %), complemented with soybean meal (11.1 %) and urea (2.3 %). In the first experimental supplement, 20 % of ground maize grain partially replaced cracked maize ears, to form the ground maize supplement (GM). For the second experimental

supplement, 18 % of molasses replaced the same proportion of cracked ear maize (SCM). Table 1 shows the ingredients and chemical composition of supplements.

Experimental cows individually received their assigned supplement (5 kg of DM/cow/d) while milking, in a cloth bag tied to their neck. All cows consumed the supplement entirely.

The experiment started on February 19th and ended on May 8th of 2015. Previous to the start, cows spent one week as adaptation period to the supplements. Then, the experiment proceeded for the next 11 wk (experimental periods).

Milk yield and composition

Milk yield was recorded on the last day of every week. After milking, cows and calves were weighted. Body condition score (BCS) of cows was determined on a 1 to 5 score scale. Milk composition (fat, protein and lactose g/kg) was determined within 2 h after milking on recording day with a portable ultra-sound milk analyser. Milk urea nitrogen (MUN) was subsequently determined in the laboratory by enzymatic colorimetry.

Feed sampling and chemical analysis

Pasture variables were determined every other week (1, 3, 5, 7, 9 and 11). Available herbage mass (AHM) (kg DM ha/d), was determined by placing six quadrants (0.25 m²), adjacent to a patch where the cows were grazing at the sampling time. Herbage mass (HM) inside the quadrants was cut to ground level with shears to determine AHM in grazing areas. From the quadrants, a 25 g sample was separated into live and dead matter, and each was weighed.

Determined pasture variables (kg DM/ha) were: available herbage mass (AHM), and its corresponding amounts of leaf (LA), stem (SA), dead matter (DMA), and live matter (LMA).

Green matter was considered live matter, and non-green matter was considered dead matter. LA and SA were estimated from the 25 g samples harvested from each quadrant by separating leaves from stems and weighing them separately. Finally, a composite sample from the six quadrants (100 g) per week was taken to determine chemical composition of pastures.

Supplements were sampled on two consecutive days at the end of every week, to determine chemical composition of a composite sample. Feed samples were dried at

60 °C to constant weight to determine DM. They were also analysed for ash, crude protein (CP) by the micro Kjeldahl method⁽¹⁰⁾. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) using the Ankom method⁽¹¹⁾. The ME of supplements and pasture was estimated using the OMD values from *in vitro* gas production, using the following equation⁽¹²⁾:

$$\text{ME (MJ/kg DM)} = (\text{OMd}) (0.0157)$$

Where:

ME = metabolizable energy (MJ/kg DM);

OMd digestibility of organic matter (g/kg DM).

The *in vitro* dry matter digestibility (DMD), organic matter digestibility (OMd), and NDF digestibility (NDFd) were determined using the *in vitro* gas production technique. Degradation fractions *a*, *b* and *L* of herbage were estimated according to the following equation⁽¹³⁾.

$$y = A \{1 - \exp[-b(t - T) - c(\sqrt{t} - \sqrt{T})]\}$$

Where:

y = cumulative gas production (mL),

t = is the incubation time in hours,

A = is the asymptote of the total gas produce (mL/g DM),

b = is the constant of gas produced per hour,

c = is a constant, and

T = is a discrete lag time in hours in that microorganisms colonize the substrate and start the fermentation.

The degradation fraction rate (μ) was calculated using the following equation⁽¹³⁾:

$$\mu = b + \frac{c}{2\sqrt{t}}, t \geq T$$

Herbage dry matter intake

Cow's herbage DMI was estimated indirectly from animal performance, taking calculations for energy requirements of milking cows from and estimated ME content of feeds from chemical analysis⁽¹⁴⁾.

$$\text{Herbage dry matter intake (kg/day)} = \frac{\text{ME}_m + \text{ME}_{ml} + \text{ME}_{lw} + \text{SupME}}{\text{Herbage ME}}$$

Where:

ME_m, ME_{ml} and ME_{lw} are the estimated ME requirements for maintenance, milk yield and live weight change, respectively.

SupME is the ME provided by the supplement (MJ/kg DM).

Herbage ME is the estimated ME concentration of herbage samples. The ME concentrations of supplements and pasture were calculated using OMD results from *in vitro* gas production⁽¹³⁾:

$$ME \left(\frac{MJ}{kg} DM \right) = (OMd)(0.0157)$$

Economic analysis

The economic analysis was performed using the partial budget approach⁽¹⁵⁾, to determine the economic profits from the use of supplements, exclusively for milk and beef (i.e. kg of weaned calves). Economic analysis results are expressed in US dollars.

Statistical analyses

The data were analysed using the MIXED procedure of SAS 9.0⁽¹⁶⁾ for a completely randomized experimental design, with cow as a random effect to account for repeated measurements on the same animal throughout the experiment.

The model used was:

$$y_{ijk} = \mu + \tau_i + \delta_{ij} + t_k + (\tau^*t)_{ik} + \varepsilon_{ijk}$$

where:

y_{ijk} = dependent variable,

μ = overall mean,

τ_i = fixed effect of treatment ($i = 1, 2$ and 3),

t_k = fixed effect of Wk ($k = 1, 2 \dots 11$),

$(\tau^*t)_{ik}$ = fixed effect of interaction between treatment i and Wk k ,

δ_{ij} = random effect of cow j within each treatment and,

ε_{ijk} = random error term.

Least squares means and standard errors for fixed effects were obtained and used for multiple mean comparisons. Significant differences between treatments were declared when $P < 0.05$.

Results

Table 2 shows the chemical composition of pasture herbage as well as *in vitro* gas production parameters. Crude protein average was 58 g/kg DM, having maximum values in wk3 and wk4 (70 and 75 g/kg DM, respectively). Dry matter digestibility (DMd) and estimated metabolizable energy (ME) had the highest values in wk 4 and wk 5 (620 and 606 g/kg DM, and 9.6 and 9.4 MJ/kg DM, respectively).

Table 2: Herbage chemical characteristics (g/kg) and gas production curve parameters

Experimental week	1	3	5	7	9	11	Mean	SD
Dry matter	701	675	648	623	694	613	651	36.8
Crude protein	50	75	70	53	46	50	58	12.1
Neutral detergent fibre	716	704	706	703	738	796	728	36.2
Acid detergent fibre	371	367	360	369	401	424	380	25.0
Acid detergent lignin	14	14	15	17	14	16	15	1.3
Dry matter digestibility	559	580	620	606	555	497	570	43.7
Organic matter digestibility	552	572	612	599	548	490	564	43.5
NDFd	489	501	523	560	526	423	517	46.4
ME, MJ/kg DM	8.7	9.0	9.6	9.4	8.6	7.7	8.9	0.7
<i>b</i>	200	198	209	213	181	160		
<i>c</i>	0.032	0.031	0.033	0.032	0.034	0.039		
<i>L</i>	5.1	5.1	5.3	5.2	5.2	5.2		

The asymptotic gas production (*b*) (mL/g DM), had the highest values in wk 4 and wk 5. The rate of gas production (*c*) showed the highest values in wk 6 (0.034) and wk 7 (0.039), whereas from wk 1 to wk 5 the rate remained constant ~ 0.032/h. Initial lag time before gas production begins (*L*) had the lowest value in wk1 (4.4), while from wk 2 to wk 7 values remained close to 5.2.

Average NHA was 11 (kg/ha/d), whereas AHM was 1,932 (kg/ha DM). Pasture morphological composition is shown in Figure 1. Green pasture represented 58 % of AHM, with an increasing trend towards the end of the study, due to some light rains; whereas leaf represented 38 % of the AHM. *Cynodon plectostachyus* was the predominant

grass representing 92 % of the botanical composition; while *Paspalum notatum* and *Paspalum convexum* represented 5 and 3 %, respectively.

Figure 1: Available herbage mass (AHM) (kg/ha DM), morphological composition (kg/ha DM) throughout experimental weeks

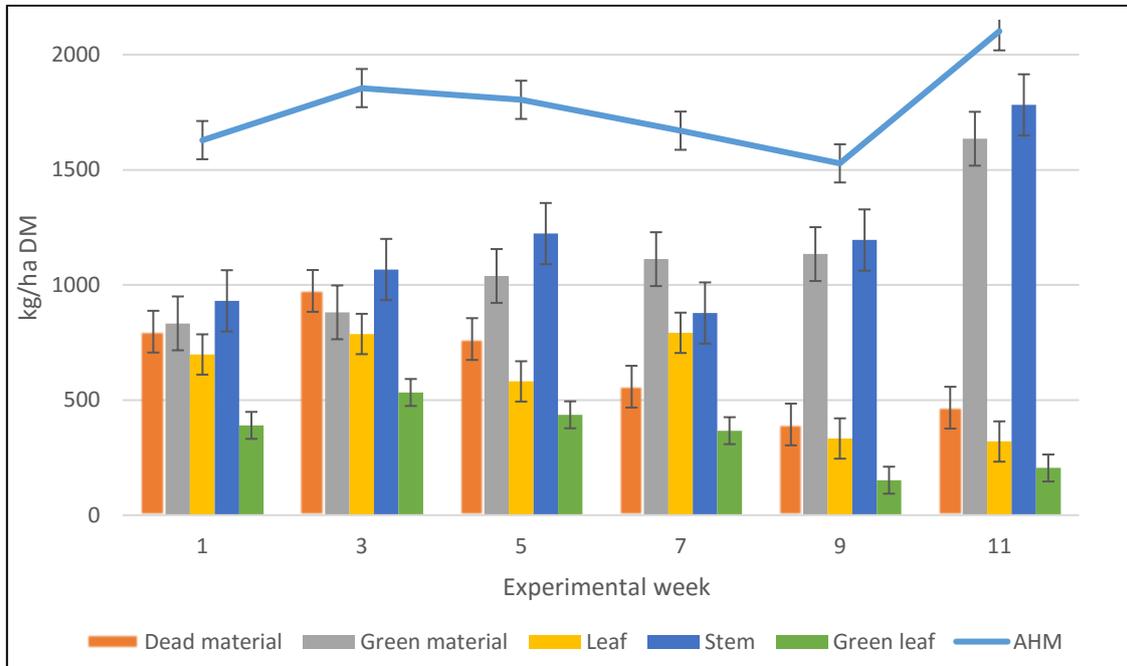


Table 1 shows ingredients and chemical composition of supplements. Average DM was 864 g/kg. Crude protein contents were 124 (CS), 113 (GM) and, 119 (SCM) g/kg DM. Neutral detergent fibre of CS was 43 % higher (379 g/kg DM) than experimental supplements (218 and 214 g/kg DM for GM and SCM, respectively).

Molasses inclusion increased values for dry matter digestibility (DMd), organic matter digestibility (OMd) and neutral detergent fibre digestibility (NDFd), as well as estimated metabolizable energy (MJ/kg DM), compared with CS and GM. SCM water soluble content represented by the *a* fraction produced higher gas volume (68.1), than CS (59.8) and GM (46.5) (Table 1). Soluble fermentation rate of CS was lower (0.098), than GM and SCM (0.128 and 0.153, respectively). Insolubles (b), which is the insoluble but potentially fermentable material was higher for GM (274.2), than CS (256.8) and SCM (255.7). The lag phase was shorter for MOS (4.2 h), intermediate for GM (5.5 h) and longer for CS (5.8 h).

Table 3 shows animal productive response variables. There were no significant differences due to treatments, with the exception of DMI and milk yield ($P < 0.01$). The effect of week was highly significant ($P < 0.01$) for all variables.

Table 3: Least squares means of animal response variables due to control supplement (CS), ground maize supplement (GM) and, sugar cane molasses supplement (SCM) on dual-purpose lactating cows during dry season

	CS	GM	SCM	SEM
Dry matter intake, kg/d	12.2 ^a	11.1 ^b	11.7 ^{ab}	0.27
Milk, kg/d	6.2 ^{ab}	5.7 ^a	7.0 ^b	0.31
Fat, g/kg	33.8	34.6	33.2	2.1
Protein, g/kg	30.5	30.5	30.6	0.19
Lactose, g/kg	42.2	43.1	42.7	0.43
Milk urea nitrogen, mg/dL	8.0	7.5	7.5	0.28
Cow weight, kg	430	406	430	16.9
Cow weight gain, kg/d	0.283	0.136	0.281	0.13
Body condition score, 1-5	1.5	1.5	1.5	0.03
Calves daily weight gain, kg/d	0.68	0.71	0.73	0.07

^{a,b,c} Means within a row with different superscript are significantly different ($P < 0.05$).

Dry matter intake (kg/cow/d) of CS was statistically not different ($P > 0.05$) from SCM (12.2 and 11.7 kg/d, respectively), but significantly different ($P < 0.05$) from GM (11.1 kg/d); whereas GM and SCM were not different from each other ($P > 0.05$).

Milk yield was statistically similar between CS and SCM with 6.2 and 7 kg/cow/d; whereas GM (5.7 kg) was different from SCM but similar to CS. There were no differences ($P > 0.05$) for the rest of the response variables. Fat, protein and lactose mean contents were 33.9, 30.5 and 42.7 (g/kg), respectively. Mean milk urea nitrogen (MUN) was 7.7 (mg/dL).

Live-weight was not different between treatments (430, 406 and 430 kg/cow, for CS, GM and SCM, respectively). Cows given CS, GM and SCM had similar ($P > 0.05$) daily weight gains of 0.283, 0.136 and 0.281 (kg/d), respectively. The average body condition score (BCS) was 1.5 points. Calves mean weight gain was 0.7 (kg/d) (Table 3).

Table 4 shows the partial budget analysis of milk and beef (weaned calves) due to supplements. Molasses supplement had a higher production cost (i.e. total supplement cost), but had better economic returns (i.e. total milk profit margin).

Table 4: Milk and beef production cost due to supplements: control (CS), ground maize (GM) and sugar cane molasses (SCM)

	Item				Mean
		CS	GM	SCM	
Milk production	Total supplement, kg/treatment	2,730	2,730	2,730	2,730
	Supplement cost, \$/kg DM	0.24	0.25	0.27	0.25
	% [‡]	-0.05	-0.01	+0.07	
	Total supplement cost, \$	655	677	660	664
	% [‡]	-0.01	+0.02	-0.01	
	Total milk yield, kg/treatment	3,260	3,041	3,713	3,338
	% [‡]	-0.02	-0.09	+0.11	
	Milk selling price, \$/kg	0.39	0.39	0.39	0.39
	Milk sales incomes, \$	1,269	1,184	1,446	1,300
	% [‡]	-0.02	-0.09	+0.11	
	Milk production cost, \$/kg	0.20	0.22	0.20	0.21
	% [‡]	-0.03	+0.06	-0.03	
	Milk's profit margin, \$/kg	0.19	0.17	0.19	0.18
	% [‡]	+0.04	-0.07	0.04	
Total milk's profit margin, \$/treatment	613	507	721	614	
% [‡]	0.0	-0.17	+0.17		
Total milk's profit margin, \$/cow	102	85	120	102	
% [‡]	0.0	-0.17	+0.17		
Beef production	Supplement, kg/treatment	601	601	601	601
	Supplement cost, \$/kg	0.24	0.24	0.24	0.24
	Total supplement cost, \$	144	144	144	144
	Beef produce, kg/treatment	371	388	399	386
	% [‡]	-0.04	0.0	+0.03	
	Beef selling price, \$/kg	3.24	3.24	3.24	3.24
	Beef incomes, \$/treatment	1,205	1,258	1,293	1,252
	% [‡]	-0.04	0.0	+0.03	
	Beef production cost, \$/kg	0.34	0.34	0.34	0.34
	Beef margin profit, \$/treatment	1,064	1,118	1,153	1,112
	% [‡]	-0.04	+0.01	+0.04	
Beef margin profit, \$/calf	177	186	192	185	
% [‡]	-0.04	+0.01	+0.04		
Total net margin profit, (\$) (milk + beef)	1,678	1,625	1,874	1,726	
% [‡]	-0.03	-0.06	+0.09		

%[‡]= Difference in relation to mean.

Beef production (kg/treatment as weaned calves) for SCM was higher (399 kg) than CS and GM (371 and 388 kg, respectively); resulting in higher beef incomes and profit margins. GM was second best for both indicators.

Overall, SCM was the treatment with higher total net profit margin from milk plus beef with \$1,874 ($P<0.01$); whereas CS came second (\$1,678) and, GM generated the lowest total net profit margin with \$1,625.

Discussion

The AHM in grazing areas remained low but constant in the grazing areas. The low but constant forage production during the experiment in spite of dry conditions could be due to water filtered to pastures from a stream that runs across the study area. This may explain in part the constant green material in grazing areas from wk1 to wk9; whereas the sharp increment was due to unusual rain at the end of the study.

In spite of these, the chemical composition of pasture across the experiment was low in terms of CP, DMd, and estimated ME. Similar chemical and agronomic characteristics of pastures dominated by *Cynodon plectostachyus*, from a nearby location to this study have been reported^(17,18).

Molasses inclusion improved *in vitro* degradability of the supplement given by the fractions *a* and *b*, resulting in 0.5 MJ of estimated ME more than CS and GM. This improvement could have had a positive impact on forage digestibility, by improving the ruminal environment due to the supply of readily available energy, which could have increased dry matter intake (additive effect), as demonstrated in previous studies^(19,20,21).

The second best supplement was CS, according to soluble fraction *a*. Better degradation kinetics were expected in the GM than in the CS, since a small particle size of maize grain increases starch digestibility (high soluble fraction)⁽²²⁾. However, CS had a higher soluble (*a*) fraction, higher insoluble (potentially degradable “*b*”) and higher insoluble fermentation rate, than GM. These could be due to higher proportion of husk and cob material in CS, which have a greater potential degradability, compared with GM.

The low milk production response of cows on GM was unexpected, since ground maize has been reported to yield more energy in rumen in the form of propionate production. Rumen propionate production has been reported as the main driver of milk in lactating dairy cows⁽⁴⁾.

One possible explanation to the low milk production response could be related to the fact that GM had about 20 % less soybean than the other two supplements. Low rumen degradable protein has been related to lower NDF digestibility^(23,24).

Furthermore, under low grass quality conditions like in this experiment, sugar cane molasses supplemented with urea, could be a better alternative than ground maize as a source of energy, since sugars are more rapidly fermented in the rumen than the starch from maize, allowing a readily supply of energy to rumen microbes. This may explain the higher soluble fraction and shorter lag phase of SCM⁽²⁵⁾.

Milk yields and milk composition in this study were lower than yields of Holstein and Brown Swiss x Zebu cows^(26,27). However, cows in both studies lost weight (~ 40 kg) and BCS, attributed to insufficient nutrients provided by the supplements; contrary to weight gained by the cows in this experiment (~ 0.233 kg/d).

In this study, treatments did not affect milk composition (i.e. fat, protein or lactose); contrary to this, reports show significant differences in protein yield (kg/d) due to a reduction in maize grain particle size that increased starch fermentation, resulting on higher propionate concentration in rumen⁽²³⁾.

Despite cows did gain weight due to supplements (average 0.233 kg/d), body condition score remained unchanged throughout the experiment (~1.5). Dual purpose cows under typical management do not receive enough energy supplies, resulting in small cow size, and limited dry matter intake capacity limiting milk yields. To overcome this situation, it has been proposed supplementation of good quality tropical grasses (0.6 to 4.4 kg/d), and supplements (between 4.0 and 5.0 kg/d), all year round. By doing this, cows will likely be on a better body condition score, (positive energy balance), particularly during critical periods like early lactation, resulting on higher milk yields⁽²⁸⁾.

It is important to note that the weather conditions during the dry season were atypical so the economic analysis should be taken with caution. From the economic point of view, molasses inclusion in the supplement increased profits from milk and beef. The small milk yield difference between these two treatments made a significant economic difference in milk and beef profit margin⁽²⁹⁾.

Combined net profit margins from milk and beef (weaned calves) were around 9 % higher for SCM compared to CS and GM. Molasses has been reported as an energy supplement that results in better milk and beef revenues^(29,30). However, these effects do not always happen. In situations when molasses is of high cost, its inclusion in dairy cow supplements represented a loss of revenue due to the small milk response⁽³¹⁾.

Farms in the study region cannot adopt any kind of forage conservation due to the steep conditions of pastures, besides the increased cost due to labour and machinery. Therefore, molasses inclusion in supplements during the dry season could be a supplementation alternative to sustain animal production performance, when forages are limited and of low quality.

Conclusions and implications

Partial replacement of cracked maize ears with sugar cane molasses, in supplements for grazing Brown Swiss dual purpose cows during the dry season, significantly increased milk yields over a supplement with ground maize. There were no differences in other animal productive response variables. Combined net profit margins (milk and calf sales) were on average 9 % higher when including sugar cane molasses in supplements.

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