Effects of substitution of kikuyu forage by oat silage on milk production and quality in dairy cows

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Abstract

Eight dairy cows, four Jersey and four crossbreed, with an average body weight (BW) of 350 kg, and in the 12th week of lactation, were assigned to two treatments (supplementation with oat silage or kikuyu forage) in a cross-over design with two periods (7 days of adaptation and 5 days of sampling per period) and four cows (two Jersey and two crossbreed) per treatment and period. Animals were daily fed, at milking, 1.5 kg dry matter (DM)/day of either oat silage or mature kikuyu forage plus a mixture of 0.9 kg DM/day of Citrocón (a commercial concentrate) and variable amounts (between 1.75 and 3.5 kg DM/day, depending on milk production) of Vapp Feed (also a commercial concentrate). Moreover, cows strip grazed kikuyu pasture (one day of grazing and 30 resting days for regrowth) and had free access to fresh water throughout the experiment. Estimated pasture intake was numerically higher (5%; $P > 0.1$) in cows supplemented with oat silage than in those supplemented with kikuyu forage, and this led to a tendency ($P = 0.0925$) to increase milk production from 14.8 to 15.6 kg/day, without variation in its composition. Daily production (kg) of protein ($P = 0.0429$) and lactose ($P = 0.0205$) was higher in cows supplemented with oat silage. Urinary excretion of purine derivatives, as an index of the microbial protein synthesis in the rumen, was not affected ($P > 0.1$) by the type of forage supplemented. As a conclusion, substitution of kikuyu forage by oat silage (on a DM basis) seems to be an advisable practice for dairy milk producers in the highlands of Costa Rica.

Keywords: dairy cows, forage supplementation, milk production, milk composition, purine derivatives

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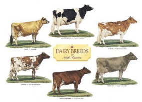
Introduction

Milk production and quality



Breed

Feed

Dairy grazing systems

Pasture and forage intake

?

Introduction

2350 m.a.s.l

Rotational grazing systems

African star *(Cynodom nlemfluensis)*

Ryegrass (*Lolium sp.)*

18,8 % CP

14,2 % DM

Kikuyu *(Kikuyocloa clandestina)*

Introduction

Energy requirements are not covered → **Concentrate and forage supplementation**

Milk production

✓ High-quality forage supplementation

Milk production

✗ Low-quality forage supplementation

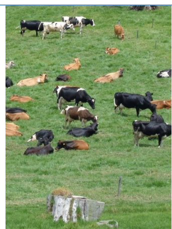
Usual in the highlands of Costa Rica

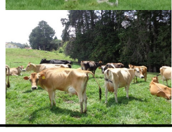
Mature kikuyu forage → **Oat silage??**

Objectives

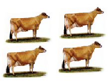
To determine the effects of supplementation with oat silage or kikuyu forage on

- kikuyu pasture dry matter intake
- milk production and quality
- urinary excretion of purine derivatives





Materials and methods



Jersey

Jersey * Holstein (50:50)

350 kg

12th week of lactation

	Period 1	Period 2
Group A	Oat silage	Kikuyu forage
Group B	Kikuyu forage	Oat silage

1.5 kg DM/day

7d adaptation 5d measurements

7d adaptation 5d measurements

+

At milking (4 and 16 h)

0.9 kg DM/day Citrocón

1.75-3.5 kg DM/day Vapp Feed

+

Kikuyu pasture

¿DMI?

Materials and methods

Sample	Analysis
Kikuyu pasture, kikuyu forage, oat silage, Citrocón and Vapp Feed	DM, CP, OM, NDF, ADF, NE_L
Milk	Fat, protein, lactose
Urine	Purine derivatives

Statistical analysis: PROC GLM of SAS v. 9.2

Model: $y = \mu + T_i + P_j + A_{k(ij)}$

T_i = fixed effect of treatment (oat silage or kikuyu forage)

P_j = fixed effect of period of supplementation

$A_{k(ij)}$ = random effect of animal nested within treatment and period

Materials and methods

DM intake estimation of kikuyu pasture

Requirements (NRC, 2001):

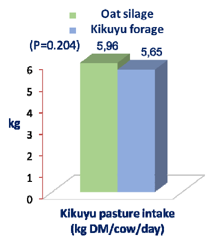
- ✓ **Maintenance: 0.080 Mcal NE_L/kg $BW^{0,75}$**
- ✓ **Milk production:**
  NE_L (Mcal/kg) = 0,0929 * % Fat + 0,057 * % Protein + 0,0395 * % Lactose
- ✓ **No changes in BW assumed (INRA, 1988)**

NE_L Requirements (per day) =
NE_L concentrates + NE_L forages + NE_L kikuyu pasture

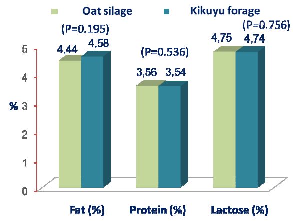
$$\frac{\text{Daily } NE_L \text{ requirements from pasture}}{NE_L \text{ content of grazed kikuyu}} = \text{Intake of kikuyu pasture (DM)}$$

Results

Pasture intake



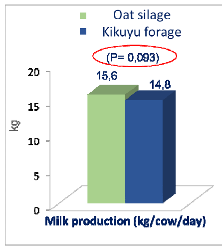
Milk composition



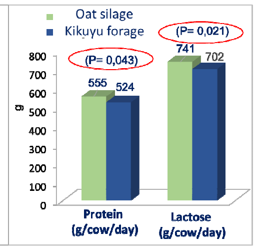
Animal effect (P<0.05)

Results

Milk production



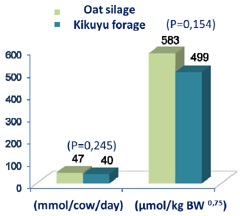
Daily production of protein and lactose



Animal effect and grazing period (P > 0.1)

Results

Purine derivatives



- Oat silage
- Kikuyu forage

→ ≈ Metabolizable fermentable energy

Xanthine
Hypoxanthine → Degradation to Uric acid Allantoin

Animal effect (P> 0.1)

Conclusion

- **Substitution of kikuyu forage by oat silage seems to be an advisable practice for dairy milk producers in the highlands of Costa Rica.**


Thank you for your attention

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Eight dairy cows, four Jersey and four crossbreed, with an average body weight (BW) of 350 kg, and in the 12th week of lactation, were assigned to two treatments (supplementation with oat silage or kikuyu forage) in a cross-over design with two periods (7 days of adaptation and 5 days of sampling per period) and four cows (two Jersey and two crossbreed) per treatment and period. Animals were daily fed, at milking, 1.5 kg dry matter (DM)/day of either oat silage or mature kikuyu forage plus a mixture of 0.9 kg DM/day of Citrocón (a commercial concentrate) and variable amounts (between 1.75 and 3.5 kg DM/day, depending on milk production) of Vapp Feed (also a commercial concentrate). Moreover, cows strip grazed kikuyu pasture (one day of grazing and 30 resting days for regrowth) and had free access to fresh water throughout the experiment. Estimated pasture intake was numerically higher (5%; $P > 0.1$) in cows supplemented with oat silage than in those supplemented with kikuyu forage, and this led to a tendency ($P = 0.0925$) to increase milk production from 14.8 to 15.6 kg/day, without variation in its composition. Daily production (kg) of protein ($P = 0.0429$) and lactose ($P = 0.0205$) was higher in cows supplemented with oat silage. Urinary excretion of purine derivatives, as an index of the microbial protein synthesis in the rumen, was not affected ($P > 0.1$) by the type of forage supplemented. As a conclusion, substitution of kikuyu forage by oat silage (on a DM basis) seems to be an advisable practice for dairy milk producers in the highlands of Costa Rica.

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Introduction

Milk production and quality depends mainly on breed and on the feed received by the animals during lactation. In dairy grazing systems, pastures and forages are the main source of feed, so the estimation of their intake is fundamental to determine the availability of nutrients needed for milk production (NRC, 2001).

In specialized dairy systems in the highlands of Costa Rica, cows' feeding is based on rotational grazing systems with pastures such as african star (*Cynodon nlemfluensis*), kikuyu (*Kikuyochloa clandestina*) or ryegrass (*Lolium sp*). However, energy requirements are not covered (Sánchez, 2007), which forces farmers to use concentrates and forage supplementation. Increments in milk production when the pasture availability is scarce are common provided the forage supplementation is adequate. On the other hand, a low milk production has been found with high levels of low-quality forage supplements (Bryant and Donelly, 1974; Davidson et al., 1982). This latter scenario is usual in the highlands of Costa Rica, where the kikuyu forage is often given at advanced stages of maturity. Substitution of kikuyu forage by a higher quality fibre source, such as oat silage, could likely increase milk production.

The aim of the present study was to determine the effects of supplementation with oat silage or kikuyu forage (*Kikuyochloa clandestina*) on kikuyo grass dry matter intake, milk production and quality, and urinary excretion of purine derivatives (PD), as an index of microbial protein synthesis in rumen, in grazing dairy cows.

Materials and methods

The experiment was conducted at a specialized dairy farm, in the highlands of the central area of Costa Rica, during July and August 2012. Eight dairy cows, four Jersey and four crossbreed, with an average body weight (BW) of 350 kg, and in the 12th week of lactation, were assigned to two treatments (supplementation with oat silage (T1) or kikuyu forage (T2)) in a cross-over design with two periods (7 days of adaptation and 5 days of sampling per period) and four cows (two Jersey and two crossbreed) per treatment and period. Animals were daily fed, at milking (04:00 and 16:00 hours), 1.5 kg dry matter (DM)/day of either oat silage or mature kikuyu forage plus a mixture of 0.9 kg DM/day of Citrocón (a commercial concentrate; C1) and variable amounts (between 1.75 and 3.5 kg DM/day, depending on milk production) of Vapp Feed (also a commercial concentrate; C2). Moreover, cows grazed kikuyu pasture (one day of grazing and 30 resting days for pasture regrowth) and had free access to fresh water throughout the experiment.

The offer and refusals of concentrates and forages given in the dairy were recorded daily, and daily aliquots of C1, C2, T1, T2, the refusals and the grazed kikuyu were taken and pooled. A representative portion of the pool was dried at 58º for 48h in a forced-air oven for DM determination. Feed samples were also ground through a 1mm screen and stored for chemical analysis. The net energy for lactation (NE_L) content of each feed was estimated according to NRC (2001) indications.

Milk production was recorded daily and samples collected to determine fat, protein and lactose contents. During the last two days of each period, urine samples were taken after each milking to analyse the concentration of purine derivatives. Sulphuric acid was added to keep the pH between 2 and 3, and samples were frozen at – 80 ºC until analysis.

Laboratory DM of feeds was obtained by drying at 105 ºC for 24, and organic matter (OM) by ashing at 550 ºC for 8 h (AOAC, 2005; Official methods 925.09B and 942.05, respectively), Total N and ether extract (EE) proportions were determined using a 2300 Kjeltec Analyser Unit (Foss Tecator) and an Ankom XT15 Extraction System (Ankom Technology), respectively, following the manufacturers' instructions. Neutral detergent fibre (NDF) was analysed using an Ankom 200 Fibre Analyzer (Ankom Technology) as described by Mertens (2002), and acid detergent fibre (ADF) and lignin (LAD) as described by AOAC (2005) (Official Method 973.18) and Robertson and Van Soest (1981), respectively. Concentrations of NDF, ADF and ADL were expressed as ash-free residues.

The contents of fat, protein and lactose in milk were determined by the methods described by AOAC (2012). The concentration of purine derivatives in urine samples was determined by high performance liquid chromatography, following the technique described by Reynal and Broderick (2009).

Intake estimations of pasture DM were obtained from the requirements of the animals (NRC, 2001), assuming no changes in BW. According to NRC (2001), maintenance energy requirements of dairy cows represent 0.080 Mcal NE_L/kg $BW^{0,75}$ in adult cows, whereas NE_L content of milk can be calculated as: NE_L (Mcal/kg) = 0.0929 * % fat + 0.0547 * % protein + 0.0395 * % lactose. Knowing the milk production (kg/day), daily individual NE_L requirements for milk production were estimated. According to the indications of the INRA (1988), it was assumed that our animals did not lose or gain weight during the 12^{th} week of lactation. Knowing the amounts of supplementary forages and concentrates consumed, their NE_L content, and the NE_L content of the grazed kikuyu, the intake of this latter was estimated.

Data were analysed using the PROC GLM procedure of SAS statistical package (version 9.2). Effects of treatment (oat silage or kikuyu forage) and supplementation period were considered as fixed effects, whereas the animal effect was considered as random. Where significant effects appeared ($P \leq 0.05$), differences among means were tested using the Tukey's test.

Results and discussion

Table 1 shows the chemical composition and the estimated NE_L of the feedstuffs used in the present experiment. Generally speaking, differences between periods of supplementation for each ingredient were lower than 15%.

Table 1. Chemical composition (as % of the dry matter) of the forages and concentrates used in both supplementation periods of the present experiment (see Materials and methods).

	OM	CP	NDF	ADF	ADL	EE	EN_L
				Period 1			
Grazed kikuyu	87.67	21.47	56.53	25.82	1.90	2.25	1.61
Oat silage	89.34	7.18	63.56	43.81	6.33	1.52	1.05
Kikuyu forage	89.38	7.52	69.53	36.93	3.78	0.95	1.14
Vapp Feed concentrate	94.15	19.70	12.34	5.67	0.31	5.24	2.12
Citrocón concentrate	93.32	6.54	19.70	18.29	1.41	1.91	1.76
				Period 2			
Grazed kikuyu	86.42	25.20	53.01	24.71	2.58	2.31	1.63
Oat silage	86.15	8.26	64.38	42.22	3.98	0.97	1.08
Kikuyu forage	86.95	7.14	65.42	49.96	4.77	1.54	1.07
Vapp Feed concentrate	93.97	19.55	12.03	5.58	0.38	4.94	2.10
Citrocón concentrate	93.45	6.51	19.02	18.15	3.99	2.01	1.69

OM: organic matter; CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; EE: ether extract; NE_L: net energy for lactation (Mcal/kg dry matter), estimated according to the NRC (2001); n.d.: not determined

As shown in Table 2, pasture intake and concentrations of fat, protein and lactose were not affected by the supplemented forage ($P > 0.1$), whereas the animal effect was significant in all cases ($P < 0.05$). Lactose concentration was higher in the first than in the second grazing period (4.78 vs. 4.71 %; $P = 0.049$). With respect to milk production, there was a trend ($P < 0.1$) to be a 5% higher in animals consuming oat silage than in those given kikuyu forage. In this case, neither individual variability nor grazing period were significant ($P > 0.1$). Daily production (kg) of protein ($P = 0.0429$) and lactose ($P = 0.0205$) (results not given in the table) was higher in cows supplemented with oat silage. Other authors (Dumont et al., 1989; Mojica et al., 2009) have shown dramatic increases in milk production when supplementing oat silage to dairy cows grazing kikuyu grass, although their level of supplementation was much higher than ours. In the present experiment, oat silage or kikuyu forage intake represented only 13.5% of the total estimated DM intake, making unlikely that the replacement of one forage by the other would cause major effects on milk production.

Urinary excretion of PD (allantoin, uric acid, xanthine and hypoxanthine), as an index of microbial protein synthesis in the rumen, was not affected by the type of forage supplemented neither when it was expressed in mmol/day (P = 0.2452) nor when it was expressed in µmol/kg $BW^{0.75}$ (P = 0.1536). This lack of differences between treatments indicates the similarity in their fermentable energy and degradable nitrogen contents available for microbial protein synthesis. The animal effect did not influence this variable (P > 0.1). It is important to highlight that it was not possible to detect xanthine or hypoxanthine in the urine of any of the animals, maybe due to degradation processes into uric acid and allantoin (Reynal and Broderick, 2009).

Table 2. Pasture intake[1], milk production and composition, and urinary excretion of purine derivatives (PD) in dairy cows grazing kikuyu grass (30 days regrowth) and supplemented with either oat silage (OS) or mature kikuyu forage (KF)

	OS	KF	SEM	P
Pasture intake (kg DM/day)	5.96	5.65	0.152	0.2036
Milk production (kg/day)	15.6	14.8	0.27	0.0925
Fat (%)	4.44	4.58	0.069	0.1951
Protein (%)	3.56	3.54	0.024	0.5357
Lactose (%)	4.75	4.74	0.019	0.7562
PD (mmol/día)	47.2	40.4	3.65	0.2452
PD (µmol/kg $BW^{0,75}$)	583	499	45.2	0.1536

[1] Estimated (see Materials and methods); SEM: standard error of the mean of the analysis of variance; P: probability of the differences; DM: dry matter; BW: body weight

As a conclusion, substitution of kikuyu forage by oat silage (on a DM basis) seems to be an advisable practice for dairy milk producers in the highlands of Costa Rica.

Acknowledgments

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