EFFECT OF A COMBINED NAPIER GRASS-OIL PALM FROND FEED ON THE *IN VIVO* AND *IN SACCO* RUMEN FERMENTATION AND DIGESTIBILITY IN GOATS

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Abstract

In Malaysia, the lack of high-quality pasture remains the main factor slowing down the development of the ruminant livestock industry. The oil palm fronds (OPF), abundant and readily available agricultural by-products, appear as a promising solution, though they are unsuitable to be used as a sole feed. Therefore, this study evaluated a combined Napier grass (NP) and OPF (NP+OPF) feed by monitoring the digestibility, *in vivo* and *in sacco*, as well as the changes of rumen fermentation parameters (volatile fatty acids, rumen fluid pH and total protozoal counts). Fifteen two-year-old male rumen-fistulated Kacang crossbed goats were used and divided into three groups, where Treatment 1 group was fed 50% NP + 50% concentrate, Treatment 2 group 25% NP + 25% OPF + 50% concentrate, and Treatment 3 group 50% OPF + 50% concentrate. Following dietary adaptation of 10 days, the *in vivo* and *in sacco* digestibility and rumen fermentation parameters were determined. Compared to the 50% NP diet, the combined NP-OPF feed showed a significantly lower *in sacco* digestibility and total volatile fatty acid production ($p < 0.05$). However, it produced good *in vivo* digestibility, rumen pH and total protozoal counts which were comparable to the 50% NP diet and significantly better than the 50% oil palm frond feed. Thus, it is concluded that the combined NP-OPF diet is suitable as a ruminant feed.

Keywords: oil palm fronds, rumen fermentation kinetics, *in vivo* digestibility, *in sacco* degradability, rumen protozoa

INTRODUCTION

Malaysia is one of the biggest producers and exporters of palm oil and palm oil products, which currently accounts for 39% of the world palm oil production and 44% of the world exports (MPOC, 2009). However, the ruminant livestock sector is growing at a slow rate due to the lack of a continuous supply of quality feed and land for the majority of the livestock producers. While the oil palm frond (OPF) has been identified as a potential feed for ruminants and other herbivores (Ebrahimi e*t al*., 2011), its low digestibility, high lignin content and low nutritive energy render it unsuitable to be used as a sole feed. Thus, this study evaluated the *in vivo* and *in sacco* digestibility, as well as assessing the *in vivo* rumen fermentation characteristics resulting from the OPF inclusion, in order to determine its suitability to be incorporated into ruminant feed.

MATERIALS AND METHODS

Animals

Fifteen rumen-fistulated, two year old Kacang crossbred male goats were used. They were housed individually in metabolism crates and divided into three treatment groups. Treatment 1 animals received 50% Napier grass (NP) and 50% concentrate, Treatment 2 animals received 25% NP, 25% OPF and 50% concentrate while Treatment 3 animals received 50% OPF and 50% concentrate. All the animals were fed twice daily (at 09:00 and 18:00) at 2.5% of body weight on DM basis. The feeds were added with liquid molasses, with water provision *ad libitum* and free access to mineral licks. After dietary adaptation of 10 days, measurements of *in vivo* and *in sacco* digestibility and rumen fermentation parameters (pH, total protozoa and volatile fatty acids) were carried out.

Determination of In Vivo Digestibility

Ten percent of the refusals and feces were sampled daily for one week and oven-dried at 60°C. The digestibility coefficient (DC) of dry matter (DM) was calculated as:

$$\text{DC of DM (g/day)} = \frac{\text{DM intake} - \text{DM voided in faeces}}{\text{DM intake}} \times 100\%$$

Determination of In Sacco Digestibility

Two grams of NP, 1.0 g of OPF and 1.0 g of NP, and 2.0 g of OPF were weighed into nylon bags (Ankom Technology, Part # R510) and incubated in the rumen for 0, 4, 8, 24, 48, 72, and 96 hours. After removal, the bags were washed in a washing machine (Panasonic, NA-F70GS) together with the zero time bags not rumen-incubated, for 40 min and dried at 60°C. Disappearance of DM was measured as the loss in weight of the bag contents.

Determination of Rumen Fermentation Parameters

Ten milliliters of rumen contents were collected before the morning feeding designated as zero hour, and at 3, 6, and 9 hours post-feeding. Rumen pH, total protozoal counts and total volatile fatty acids were measured.

RESULTS AND DISCUSSION

All treatment groups did not exhibit significant differences in the pH of the rumen fluids (Table 1). Nevertheless, the feeding of NP-OPF combination yielded the highest mean rumen pH values compared to the other two groups. Furthermore, the combined NP-OPF feed produced rumen pH values ranging from 6.17 - 6.73 which indicated that effective fiber digestion had taken place (Orskov and Ryle, 1990).

Table 1. Rumen fluid pH from fermentation of different diets

Time (h)	Napier 50%	Napier 25% + OPF 25%	OPF 50%
0	6.58 ± 0.12	6.67 ± 0.15	6.91^{x} ± 0.13
3	6.24 ± 0.13	6.28 ± 0.08	6.07^{y} ± 0.15
6	6.26 ± 0.09	6.17 ± 0.24	6.29^{y} ± 0.08
9	6.41 ± 0.17	6.73 ± 0.11	6.30^{y} ± 0.13

All values are expressed as Mean ± SE (n = 5)
$^{x,\ y}$ Means columns differed significantly at $p< 0.05$ due to time effect
OPF=oil palm frond

Table 2. Total volatile fatty acid production (mMolar) from fermentation of different diets at different hours

Time (h)	Fatty acid (mM)		
	Napier 50%	Napier 25% + OPF 25%	OPF 50%
0	35.93^{a} ± 3.01	$30.02^{b,x}$ ± 2.49	$30.36^{a,b,x}$ ± 2.21
3	54.23^{a} ± 4.58	$52.33^{b,y}$ ± 3.34	$60.43^{a,b,y}$ ± 4.10
6	52.26^{a} ± 4.49	$39.98^{b,x}$ ± 2.10	$42.73^{a,b,z}$ ± 2.75
9	46.00^{a} ± 7.57	$31.10^{b,x}$ ± 1.57	$36.04^{a,b,x,z}$ ± 2.48

All values are expressed as Mean ± SE (n = 5)
$^{a,\ b}$Means within row differ significantly at $p< 0.05$ due to treatment effect
$^{x,\ y,z}$ Means within column differ significantly at $p< 0.05$ due to time effect
OPF=oil palm frond

The *in vivo* fermentation of the NP 50% produced the highest total volatile fatty acids (VFA) at the zero, sixth and ninth hour post-prandially (Table 2), in line with its high digestibility. The OPF with higher lignin content (13-25%) resulted in a lower microbial production of VFA in the OPF 50% group as lignin restricted the degradability of structural polysaccharides by the microbial hydrolytic enzymes, thereby limiting the bioconversion of OPF fiber into VFA (Brown, 1985; Jung and Deetz, 1993). This OPF-NP combination produced the least amount of VFAs, in contrast with its highest *in sacco* degradability in the first 12 hours of rumen incubation (Table 4). Since the sampling for VFA measurement was carried out within the time frame where the *in sacco* digestibility was at the highest, a rapid rate of VFA absorption from the rumen might have occurred to explain the above finding. This study confirmed the inverse relationship between increasing pH value and decreasing total VFA concentration (Pamungkas *et. al.*, 2006).

The combined NP-OPF feed had a lower but statistically comparable *in vivo* digestibility with the NP 50% diet (Table 3).

To evaluate the OPF inclusion with NP, not only was the *in sacco* degradability (Table 4) of the NP-OPF combined diet close to 40% at 48 hours, but significantly higher than that of the OPF 50% diet at all times where it approached the NP 50% diet at 96 hours. As expected, the NP 50% showed the greatest *in vivo* dry matter digestibility, significantly different from the OPF, again confirming the higher cell-wall lignification of the OPF since the digestibility of forage in the rumen is related to the proportion and extent of lignification (Van-Soest, 1994).

Table 3. *In vivo* dry matter digestibility of different diets

	Napier 50%	Napier 25% + OPF 25%	OPF 50%
DM Digestibility (%)	$89.06^{a} \pm 1.18$	$78.80^{a,b} \pm 2.99$	$56.39^{b} \pm 4.32$

All values are expressed as Mean ± SE (n = 5)
*[a, b] Means within row differ significantly at $p < 0.05$ due to treatment effect

Table 4. *In sacco* dry matter degradability (%) of different diets

Time (h)	Dry matter (%)							
	0	4	8	12	24	48	72	96
Napier	20.5±0.3	$21.3^{a,w}\pm0.4$	$22.6^{a,w}\pm0.4$	$27.3^{a,w,x}\pm1.2$	$38.9^{a,w,y}\pm2.0$	$51.9^{a,y,z}\pm4.2$	$55.6^{a,z}\pm4.4$	$58.3^{a,z}\pm4.4$
Napier ±OPF	20.4±0.4	$22.0^{b,v}\pm0.3$	$23.8^{b,v}\pm0.8$	$28.1^{b,v,w}\pm0.8$	$34.4^{b,w,x}\pm0.6$	$38.5^{b,w,y}\pm1.5$	$46.5^{b,y,z}\pm2.3$	$54.5^{b,z}\pm5.3$
OPF	15.3±0.7	$17.0^{c,w}\pm1.7$	$17.5^{c,w}\pm1.6$	$18.5^{c,w}\pm 1.6$	$20.5^{c,w}\pm1.1$	$22.2^{c,w,x}\pm1.7$	$24.8^{c,w,x}\pm1.6$	$28.5^{c,x}\pm1.5$

All values are expressed as Mean ± SE (n = 5)
*[a, b,c] Means within row differ significantly at $p < 0.05$ due to treatment effect
[w,x,y,z] Means within column differ significantly at $p < 0.05$ due to time effect

Table 5. Total protozoal counts in goats fed different diets

Time (h)	Protozoal count (10^6 cells/mL)		
	Napier 50%	Napier 25% + OPF 25%	OPF 50%
0	$0.68^{a} \pm 0.22$	$0.46^{a} \pm 0.11$	$0.36^{b} \pm 0.20$
6	$0.57^{a} \pm 0.23$	$0.64^{a} \pm 0.13$	$0.29^{b} \pm 0.09$
9	$0.65^{a} \pm 0.21$	$0.62^{a} \pm 0.08$	$0.32^{b} \pm 0.17$

All values are expressed as Mean ± SE (n = 5)
[a, b] Means within row differ significantly at $p < 0.05$ due to treatment effect
OPF=oil palm frond

In conclusion, the 25% OPF-25% NP combination was shown to be suitable for goats as reflected by its good *in vivo* digestibility and satisfactory *in sacco* degradability, as well as acceptable rumen pH values and total protozoal counts (Table 5).

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